

COMPENDIUM OF RESEARCH IN TEACHER EDUCATION

Selected research on teaching, learning, mathematics education,
science education, mentoring, community engagement,
and applied educational research

COLLEGE OF EDUCATION

Bicol State College of Applied Sciences and Technology
Naga City, Philippines

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A curated collection of selected studies
from educational, scientific, mathematical,
and community-based research contexts

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Naga City, Camarines Sur, Philippines

EDITORIAL NOTE

This expanded edition brings together eighteen selected research articles in a single book-format publication. The additional studies broaden the collection to include growth mindset and supplementary mathematics materials, global mathematics teaching approaches, Alternative Learning System sustainability, participatory action research mentoring, technology-supported science learning, graphic organizers in chemistry, metacognition in science teaching, and an interdisciplinary review on plant-derived silver nanoparticles. Original article pages are retained while a common visual framework, section openers, running identity, page numbering, and navigation bookmarks provide a uniform book presentation.

Design and preservation principle

The compendium standardizes presentation without rewriting the source studies. Each article remains a distinct scholarly contribution, identified by its original title, authorship, publication information, and original page content.

Publication and Editorial Information

Annual Publication

The Compendium of Research in Teacher Education is published annually as a curated collection of scholarly works in teacher education and related fields.

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RESEARCH ARTICLE 01

Program for Enhancing Resilience to Climate Change: A Basis for School-Community Partnership

Margie A. Nolasco, Yolanda P. Beguia, Elsa E. Durante,
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Asia Pacific Journal of Multidisciplinary Research, 3(4), 158–166

Original publication: 2015

Program for Enhancing Resilience to Climate Change: A Basis for School-Community Partnership

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Asia Pacific Journal of
Multidisciplinary Research
Vol. 3 No. 4, 158-166
November 2015 Part V
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

Date Received: October 25, 2015; Date Revised: November 17, 2015

Abstract - Naga City in the Philippines as the catchment area of the Bicol River, Naga City Disaster Risk Reduction and Management Office (NCDRRMO) has been actively addressing issues on climate change. Despite of local emergency response team's efforts, people's exposure to threat, increases. Significant impact can be made for climate change advocacies if there is appropriate and effective school-community collaboration. This provides challenge to all Higher Educational Institutions (HEIs). This paper evaluated the status of DRRM in the school and community. This also considered the extent of partnerships so that strategies could be made to help the community address problems in response to climate risk. The study adopted descriptive-evaluative design of mixed methods of research. The methods were utilized to confirm and validate findings. Structured questionnaires, interviews and FGDs were used for data gathering to the selected respondents of HEIs and Barangays in Naga City. Based on the findings of the study, respondents were "slightly prepared" for the exposure to climate change; collaborative efforts as one of the practices of the schools-LGUs in helping the community. Nevertheless, negative attitudes and no ample time to attend the seminar of the households as the problem encountered by schools-LGUs. As a result, inter-agencies collaboration should be established to address climate change related issues. The adoption of Buronyog sa Pag-Anduyog: A School-Community Initiatives for Climate Change will give opportunities to the community-beneficiaries be equipped with skills to address climate change impact.

Keywords: Climate Change, partnership, School-Community

INTRODUCTION

Many lives are endangered and properties are lost when disasters of great magnitude strike. The changing climate has been a global issue [1] because there are unpredictable effects on the people. Naga City as the catchment area of the Bicol River and constantly hit by the typhoon every year. Its local government office has been actively consolidated their efforts this addressing such issues. Despite of the hard works, people's exposure to threat, increases. Although, there are well established Disaster Risk Reduction (DRR) policies and strategies that address all forms of hazards [2]. But, the current technology in our country is insufficient to detect it, and not all people fully understand the adverse effects of natural disasters by their exposure to them. A provision, [3] the government should adopt a holistic, comprehensive, integrated, and proactive DRRM approach and promote the involvement and

participation of all sectors and all stakeholders concerned, at all levels, especially the local community. This is one way of strengthening it for a sustainable Climate Change advocacy.

Recent reviews indicate that over the past few decades, the challenge of reducing socio-economic vulnerability to climate has been taken on by researchers and policy communities [4]. Besides Lasco [5] confirmed the key role of local governments in promoting climate change adaptation by means of provincial resources to commit to climate change adaptation. But still, there is one aspect in this country that is not well studied, the potential of inter-local government collaboration for disaster risk reduction [6]. This study is the gap that would attempt to address.

Education is the essential component of adaptive capacity for climate change [7] Highly educated

individuals and societies are reported to have better preparedness and response to the disasters, suffered lower negative impacts, and are able to recover faster[8]. It is because through teaching-learning, the school has capacity not only to influence the community on how to reduce the effect of disasters occurring but also provide them necessary knowledge and skills in CC resiliency.

Risks can be changed by modifying the initial event or activity or by mitigating their impacts [9]. Adverse impacts of natural hazards may be reduced if there is appropriate and effective school-community collaboration. In general, adaptation practices depend for their success on specific institutional arrangements -- adaptation never occurs in an institutional vacuum [10]. This provides challenge to all Higher Educational Institutions (HEIs) not only in the City but also in neighboring towns. Moreover, the schools-LGUs partnership is also the key element for people's adaptation to climate risk. Though the help of the key stakeholders like Barangay Captains, Naga City Disaster Risk Reduction (NCDRR) Taskforce and Institutional Extension Directors and School personnel, this paper evaluated the status of DRRM in the school and community and the extent of its partnership so that strategies could be made to help the community address problems and issues in response to climate risk.

OBJECTIVES OF THE STUDY

This study evaluated the status of Disaster Risk Reduction Management (DRRM) in the school and community and the extent of its partnerships in increasing community's resilience to climate change. Specifically, the study attempted to: (a) determine the level of preparedness of Barangay Officials, School Personnel, and Household Heads on their exposure to climate change; (b) identify the practices of the schools and LGUs in helping the community in climate change adaptation; (c) predict the problems encountered by the school-community in the implementation of DRRM; and (d) propose a school-community partnership program for enhancing resilience to climate change.

METHODS

The study adopted descriptive-evaluative design of mixed methods of research [11]. Two different methods were utilized to confirm, cross validate or corroborate findings in determining the extent of school-community partnership in enhancing resilience

to climate change for the year 2014-2015. The data and information of this study was generated from the responses of the two hundred and ninety-seven (297) household heads, thirty-nine (39) LGUs of the selected barangays and one twenty-one (121) School Personnel of the selected HEIs and Barangays in Naga City respectively, through the use of random sampling. Selected barangays which consist of almost one-third of the total population of Naga City were identified considering their exposure to the different levels of climate related risks (high, moderate and low level of risk). Slovin's formula was used in obtaining the required sample size of the population for both selected HEIs and Barangays in Naga City.

The data and information were collected using a questionnaire-checklist to the LGUs, Household Heads and School Personnel. The questionnaire was composed of two parts the first part was the profile of the respondents and the second part were the series of questions aimed to determine the practices of the school and LGUs in climate change adaptation and its problems encountered. It has also items or statements that described aspects of exposure to climate change levels of preparedness. It contained four items, which were scored on a four-point Likert scale.

Table 1. Level of Preparedness range of scale with verbal description

Weight	Scale	Description
4	4.00-4.99	- Always Prepared
3	3.00-3.99	- Somewhat Prepared
2	2.00-2.99	- Slightly Prepared
1	1.00-1.99	- Unprepared

Its total scores ranged from 1 to 4 and has the following scale: Always Prepared or four (4) described as respondents were organized or equipped and ready all the time; Somewhat Prepared or three (3) which means respondents were organized and ready often or most of the time; Slightly Prepared or two (2) which means respondents have inadequate preparations; and Unprepared or one (1) respondents were not prepared (see Table 1). Interviews and Focus Group Discussions (FGDs) with key stakeholders like Barangay Captains, Naga City Disaster Risk Reduction Taskforce and Institutional Extension Directors were also used to generate different ideas from them. These were conducted concurrently to validate quantitative results used as bases for generalization of research outcomes; hence, mixed method of data collection was obtained. Review of

related documents was also considered. Data gathered were statistically interpreted using frequency count, percentage and weighted mean. They were analyzed and presented in graph and tabular form.

RESULTS AND DISCUSSION

The weather in Naga City from June to October is the typhoon season and it is generally rainy. The city also has a high exposure to tropical cyclones. Records show that it is hit by an average of 2.7 typhoons a year. It is second to Tacloban City, Philippines (6.74) in being the city most vulnerable to climate change among four (4) assessed by the study [12]. Its city proper is also within the catchment area of the Bicol river basin. Climate change such as typhoon triggers the Bicol River to overflow which caused flooding in some parts of the city.

Level of Preparedness on the Exposure to Climate Change

An Organized and well-coordinated disaster units is one of the strengths in Naga City. It also has strong implementation on leadership trainings and seminars on Disaster Risk Reduction and Management (DRRM), just like the seminars conducted every now and then.

Table 2. The Level of Preparedness of the Barangay Officials/LGUs

Item	Mean	Description
Trainings & seminars to people undergoing operations	2.88	Slightly Prepared
Trainings and seminars to the community	2.71	Slightly Prepared
Mobilize the different DRRM taskforce	2.91	Slightly Prepared
Organized & well-coordinated disaster units.	2.96	Slightly Prepared
Average	2.85	Slightly

Barangay Officials/LGUs. Shown in Table 2 are the results of the Level of Preparedness of the Barangay Officials/LGUs on the Exposure to Climate Change. Naga City has an organized & well-coordinated disaster unit, but with ($\bar{x}=2.96$) Barangay Officials/LGUs were “slightly prepared” for disaster events. Although there were lot of seminars conducted every now and then to DRR taskforce but still, they were “slightly prepared” or (2.91) to mobilize the

different DRRM taskforce before, during and after disaster; likewise to conduct trainings & seminars to people undergoing disaster related operations (2.88). And with 2.71, they were also “slightly prepared” and to conduct trainings, seminars & drills to community-beneficiaries like households, Out of School Youths (OSY) and senior citizens about climate hazard and specific preparedness measures. Still, most of the Barangay Officials/LGUs in Naga City were slightly prepared” for the exposure to climate change.

One of the functions of LGUs is to engage in government’s disaster risk reduction programs towards effective delivery [13] Its responsibility is to organize a community-based program in capability-building on climate change so that community should deepen their understanding to the climate change and make locally-based approaches for addressing climate change impacts. However, validation reports from key persons through interviews and FGDs, it revealed that LGUs in Naga City haven’t yet conducted trainings, seminars, exercises & drills to the households about climate change preparedness measures.

Household heads. Naga City is second to Tacloban City (6.74) as cities most vulnerable to climate change. Records show that it is always hit by an average of 2.7 typhoons a year [14]. That is why, the ability of its people to achieve regular routine after a major climate change-related event is quite high. Thus, it is reflected in table 3 that among the four(4) categories, household heads perceived “*somewhat prepared*” or “*organized and ready often or most of the time*” in the practice of the emergency plans before disaster comes and ($\bar{x}=3.17$); aware of the responsibilities in addressing possible disaster related risk of 3.31 respectively. But unfortunately “*slightly prepared*” in attending trainings, seminars and drills conducted by the local government (2.41) and volunteer in the undergoing disaster related operations (2.42). And with the average mean of 2.8, this proves that most of the household-respondents perceived that they were “*slightly prepared*” on the exposure to climate change.

Perceptions of risk and structural inertia in planning processes have emerged as key issues for implementing adaptation responses [15]. Politicians, government agencies, and community leaders were all faced in different conflicting priorities. Sadly, climate change related problems and issues were almost neglected. This maybe one of the reasons behind

among different barangays, few people attended DRR trainings and seminars.

Table 3. The Level of Preparedness of the Household heads

Item	Mean	Description
Practice the emergency plans.	3.17	Somewhat
Attend trainings, seminars and drills conducted by the local government.	2.41	Slightly Prepared
Aware of the responsibilities in addressing possible disaster related risk.	3.31	Somewhat Prepared
Volunteer in related operations.	2.42	Slightly Prepared
Average	2.8	Slightly

Thus, enhancement of local-based policies should be given so much attention for an improved DRR delivery. The participatory planning approach in DRR should also be considered so that each person has the responsibility in addressing possible climate change hazards.

School Personnel. There have been activities in preparedness measures to disaster related events like fire and earthquake drills that are being conducted in every school within the City. That is why, it reflected that school personnel were “*somewhat prepared*” or “*organized and ready often or most of the time*” in the integration of DRR in school curriculum with ($\bar{x}=3.07$). However, they were “*slightly prepared*” to coordinate with the LGUs in disseminating information (2.83) and strengthening climate change adaptation through informal education with 2.94. Moreover, they were “*slightly prepared*” in the initiating community-school partnerships in addressing disaster related events (2.96). As a result, most of the school personnel were “*slightly prepared*” in preparation for the exposure to climate change. The findings were summarized in Table 4.

Table 4. The Level of Preparedness of the School Personnel

Item	Mean	Description
Integration in school curriculum.	3.07	Somewhat Prepared
Climate change in informal education.	2.94	Slightly Prepared
Coordinates with the LGUs.	2.83	Slightly Prepared
Initiates community-school partnerships.	2.96	Slightly Prepared
Average	2.95	Slightly

An active DRR promotion and implementation would facilitate the restoration and rehabilitation to the disaster-stricken communities. In such, there are activities in the different schools in Naga City would enhance the awareness of students and personnel on how to cope with disaster related events. However, there should also be an active coordination between and among the LGUs, GOs, NGOs and PDCC member agencies for effective DRR implementation.

The Practices of the School and LGUs in Helping the Community in Climate Change Adaptation

Adaptation and cooperation are the basic and often in the interests of survival [16]. That is why, Provinces in the country, that have experienced climate hazards are now a days more aware and responsive of the needs for climate change adaptation. Climate change is fast pushing the poorest and most marginalized communities beyond their capacity to respond. This report draws on case studies from around the world and on Oxfam’s experience working with rural communities. It sets out what is needed to enable people living in poverty to adapt to climate change, and a range of interventions that are available [17]. The technical services rendered of the different schools and LGUs resources will be of great help for disaster risk awareness so that they will be more prepared to face climate change.

Information Dissemination. Among 297 household heads, 39 Barangay Official-respondents and 121 school personnel, 30% perceived that there were “collaborative efforts of the school and LGUs in providing the community about the regular updates on climate change”; then 24.2% assumed that accessible disaster operation center as one of the practices. They believed that “conducts trainings and seminar about climate hazard” with 23.4% as the practices. Although some schools in Naga City have focal persons in DRR yet, most of them do not have established office that would cater on climate change related problems.

Their Community Extension Offices are focused on livelihood and other capability enhancement trainings. That is why, only 21.2% agreed that schools-LGUs have an active disaster management office. There were a lot of trainings done by the City DRRM office to the barangay task force and local authorities and some youth volunteers. Unfortunately, self-awareness in disaster related events as their least priority. But, still respondents agreed that

“Collaborative efforts of the school and LGUs in providing the community about updates on climate change” is one of the practices of school-community in helping them in climate change adaptation in terms of information dissemination as reflected in Figure 1.

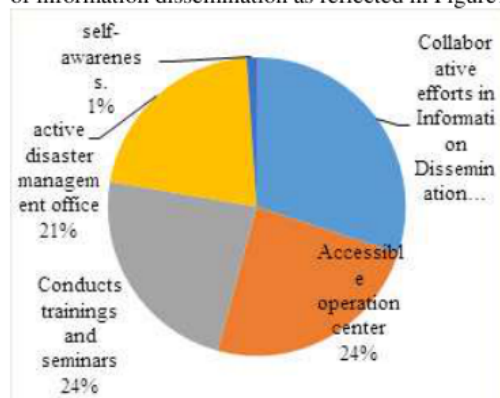


Figure 1. The practices of the school and LGUs through information dissemination.

Trainings done by the NCDRRMO to the barangay task force and local authorities were not enough to prepare the local communities enhance capacities to climate change risk and reduce its level of vulnerabilities. People who directly suffered from disaster risk should also be considered. Community-based activities and locally "owned" strategy should be established with household members as beneficiaries to minimize the effects of climate change.

Policies and Mitigating Practices. Figure 2 provides the data on practices of the school and LGUs in helping the community in climate change adaptation in terms of policies and mitigating practices. Among thirty-nine (39) Barangay Officials/LGUs-respondents, and (121) school personnel and (297) households; more than 25.2% agreed that there were flexible and easy to understand policies and practices made by them in helping the community about DRR. Then 17.7% believed that there were concrete strategies on how to address issues in climate change adaptation.

Moreover, collective efforts of schools and barangay in strengthening climate change management program as one of the practices of the school-community help strengthen climate change resilience with 17.7%. And 16.7% perceived that both have effective implementation plan of activities.

Remarkably 13.8% and 8.9% “integration of DRRM policies in the school development plan and adopt national policies on disaster management as their least priorities.

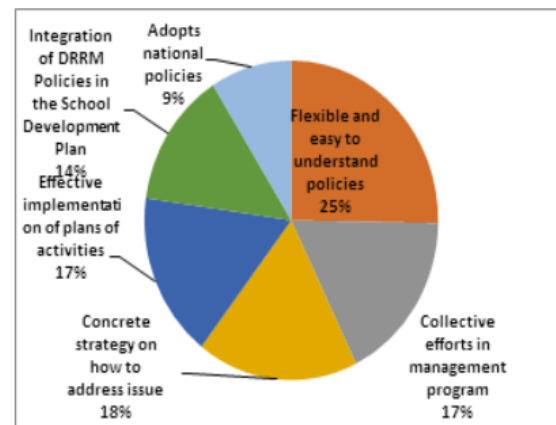


Figure 2. The practices of the school and LGUs through policies and mitigating practices.

HEIs could be of help for disaster response activities. Yet, activities in climate change were not HEIs priority because of some overlapping schedules and time management problems. Hence, most of the respondents believed flexible and easy to understand policies are the practices of school-community in helping the community in climate change adaptation. So far, National Disaster Risk Reduction and Management, empowered local governments to prepare their DRRM plans and utilize at least 5% of their annual budget to support these plans (Republic Act No. 10121).

Monitoring and Evaluation. In Naga City, emergency preparedness, until now has traditionally focused on stockpiling relief goods and providing urgent services to meet the community's basic needs during the course of hazards. That is why; data revealed in Figure 3, of the 4 common practices, registered, the highest frequency of 28.2% two groups (school and LGUs) perceived that community is encouraged on the utilization of early warning system as their top priority.

Whereas, 27.4% agreed that their practice is to “assess impact on the community about the programs made”. It is followed by “evaluate implementation plans (23.2%)”. Unfortunately, “come up with the strategies to address issues of the vulnerable

community” belong to the last rank, since; local Administrators are more focused on short-term emergency contingencies.

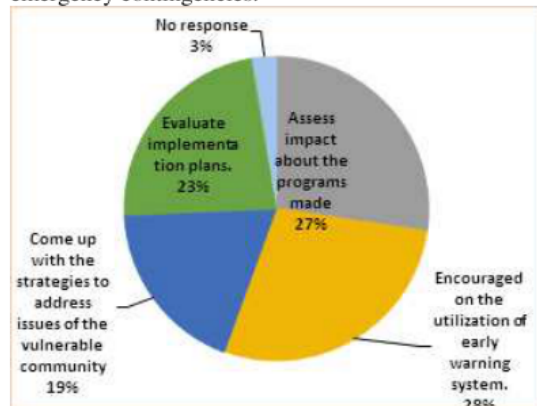


Figure 3. The practices of the school and LGUs through monitoring and evaluation.

Thus, most of the respondents' perceived community is encouraged on the utilization of early warning system as the practices of the school and LGUs in helping the community in climate change adaptation. Moreover, based from the perception of the interviewed LGUs none of the agencies come up with the strategies to address issues in climate change of the vulnerable communities within the city.

It is true that Early warning systems are highly effective in saving lives and livelihoods. It provides communities with the advance information of risks that can be readily translated into prevention, preparedness and response actions. But then, building up strategies to capacitate humanitarian response should be a priority for all agencies. This should put much greater attention on long term approach in emergency preparedness and risk reduction, focusing on those communities most at risk. It helps also to reduce economic losses by allowing people to protect their assets and livelihood. These need to be strengthened in Naga City.

The Problems Encountered by the School-Community in the Implementation of DRRM

As perceived by the LGUs. Managing in general depends on leader's political will [18]. And the problems encountered by it, can be linked by leader's own priorities. Table 5 shows the problems encountered by the school-community in the implementation of DRRM as perceived by the LGUs.

Table 5. The problems encountered by the school-community on DRRM Implementation.

As perceived by LGUs	%
Lack internal revenue allotment	14
Not priority of the barangay	5
Scarcity of DRR emergency supplies	12
Negative attitude of the Community	11
No available funds from the national government.	13
Negative attitudes of some households	22
No ample time to attend seminar	20
No answer	1
Total	100

As reflected, 22% of Barangay Officials agreed, that the biggest problem that they have encountered is having negative attitudes of some households about the program in DRR. While 20% believed that households have 'no ample time to attend seminar' and 14% were convinced that they "Lack internal revenue allotment on DRR". Only few or 5% assured "not barangays' priority" as one of the problems encountered by the school-community in the implementation of DRRM. This proves that most of the Barangay Official/LGUs-respondents, encountered having negative attitudes of some households about the program related to information dissemination in DRR.

As perceived by Household Heads. We can observed that HEIs tend to focused on academic aspects while some politically affiliated community leaders are more focused on activities that make them gain votes. Hence, the negative attitudes of households towards DRR implementation can be associated by stakeholders' priorities.

Table 6. Problems encountered by the school-community on DRRM Implementation

As perceived by Household Heads	%
Lack internal revenue allotment	11
Politically motivated LGUs	12
Not priority of the barangay	11
Scarcity of DRR emergency supplies	12
Negative attitude	10
Lack of initiatives	12
No available funds from the national government	8
Negative attitudes of households	10
No ample time	15
TOTAL	100

Table 6 shows the problems encountered by the school-community in the implementation of DRRM as perceived by the household heads. Naga City is Bicol Region's trade business center. For that reason, among 297 household heads, 15% confirmed they do not have time to attend the seminar on Climate Change.

Lack of initiatives of community leaders, scarcity of DRR emergency supplies and politically motivated LGUs with 12% are among the top responses. Only 8% attested that there are no available funds for DRR coming from the national government to support its implementation. Thus, this proves that most of the household-respondents do not have time to attend the seminar on Climate Change

As perceived by School Personnel. Lack of access to DRR information can also be the result of the increase in the level of vulnerability. It can happen simply because people don't find time to attend seminars in climate change. In such, personal priorities are not necessarily the main reasons, but also lack of initiative from DRR taskforce or local leaders, and community's negative perception to LGUs. If not, community may not know where to turn for assistance in times of distress. Nevertheless, it is always the responsibility of individuals to know and understand disaster and climate change related issues.

Table 7. Problems Encountered by the School-Community on DRRM Implementation

As perceived by School Personnel	%
No school-community collaboration	8
Availability of emergency implementation plan	14
Awareness of disaster operations center	13
Lack of specific time allotment for such topics	9
Lack of DRR learning materials	10
Congested curriculum	4
Overlapping school activities	13
Hectic schedule of teachers	14
Negative attitude of some teachers	4
Not a school's priority.	6
Lack of initiatives from the administration	4
Others like Self awareness	1
Total	100

Since, most of the schools in Naga City are focused in teaching instructions and don't have yet established implementation programs; that is why among 121 responses of school personnel-respondents, 14% confirmed availability of disaster risk reduction emergency implementation plan; and hectic schedule of teachers for instructional activities

were the problems encountered. Moreover, 13% believed that overlapping school activities and lack of awareness on disaster operation center were the problems encountered. And few believed lack of initiatives from the administration, negative attitudes of teachers and congested school curriculum were the problems encountered (see Table 7).

The Proposed Program in Enhancing Resilience to Climate Change

1. Title: **BuronyogsaPag-Anduyog(unity in helping):A School-Community Initiatives for Climate Change**

2. Rationale

Environmental challenges do not change the role of education; it rather changes its quality. Education must address global issues like climate change. This should be considered by the educational managers so that knowledge, life skills and values of students will be developed. Moreover, series of community-based activities have proven effective if there is school-community collaboration and cooperation.

Buronyog sa Pag-Anduyog is a collaborative efforts of HEIs and LGUs in helping communities be resilient to Climate Change. Through this, existing DRR programs and projects of the LGUs can be utilized considering the needs of the particular community. Moreover, through the help of LGUs and other stakeholders, HEIs will offer technical services to the community-beneficiaries (farmers, fisherfolks, OSY and other household members) about the updates, preparedness measures and mitigating process on climate change. In this way, communities in selected barangays in Naga City and Camarines Sur will be aware and be prepared of DRR and climate change risk.

3. Objectives

Provide opportunities to the communities to be equipped with necessary skills to address climate change impact on the local level. Specifically, it will be able to:

- Acquire basic knowledge on climate hazard and specific preparedness measures;
- Address the issue of disaster preparedness seriously; and

- c. Create local-based activities that will further enhance the capacity on Climate Change problems risk reduction of every community.

4. Description of the Initiative Components

Initiative 1: School-Community Partnership

The established collaborative approach of HEIs and LGUs in helping the community be resilient to climate change will start on November 2015. The first Naga City and Camarines Sur HEIs-LGUs and Other Agencies' organizational meeting will be held at BISCASST Naga City. The inception consultative conference will focus on (1) identifying DRR and climate change common problems based on the research findings; and (2) the creation of multi-disciplinary strategies in addressing climate risk. Partnerships will be formalized through signing of the Memorandum of Agreement (MOA) to clear out roles and responsibilities before, during and after the conduct of capacity enhancement and livelihood training. It is expected to expand gradually all throughout Bicol Region with the help of CHED, NDRRC, LGUs and other agencies and stakeholders as partners.

Initiative 2: Training-Workshop for HEIs Teachers and Student Volunteers

National Disaster Risk Reduction and Management Council (NDRRMC) pool of experts will be invited to share their knowledge and expertise on DRR and climate change to HEIs teachers, extensionist and student volunteers through training-workshops. Thus, they could help the community to improve its capacities in DRR and climate change hazards.

Initiative 3: Capacity Enhancement Activities for community-beneficiaries:

a. *Trainings and Seminars*. This is a series of trainings and seminars as one of the initiatives of HEIs and LGUs that focuses on providing the community about the regular updates on climate change. This will help them strengthen their preparedness/resilience to disasters and climate risk.

b. *Climate Awareness Resource Education (CARE) Mobile Center*. The Climate Awareness Resource Education (CARE) Mobile Center, is designed to educate communities on climate hazards and specific preparedness measures by reaching out people in the

community through house to house visit and giving of educational resources. This will enable the extensionists/volunteers reach busy households and distant communities with lack of accessibility to any information dissemination about climate change updates because of geographical location.

Initiative 4: Livelihood Options

Many people of the affected communities are unable to engage in normal income generating activities after disaster and climate change phenomena. They normally became dependent on humanitarian aid. That is why, livelihood opportunities to affected communities are essential component for economic reconstruction. Livelihood opportunities will be conducted to the selected communities. This HEIs-LGUs initiative will help them secure alternative occupation or vocation and income generating opportunities and if possible, provide means to start a project. In this way, this will provide direction to vulnerable communities rebuilding their economic situations after disaster.

CONCLUSION AND RECOMMENDATION

Based from findings of the study, the following conclusions/ implications are deduced: The barangay officials, household heads and school personnel are "slightly prepared" on the exposure to climate change; the collaborative efforts in providing the community about its updates was one of the practices done by the school and LGUs in helping the community in climate change adaptation; negative attitudes of some households as one of the problems encountered by the School-LGUs in DRR implementation; and a need for school-community partnership program as blueprint for enhancing resilience to climate change.

Thus, it maybe implied that: (1) implementation strategies of National Disaster Coordinating Council (NDCC) for Local Government should be revisited to support ongoing, proactive adaptation to climate change risks; (2) Disaster Risk Reduction (DRR) policies and framework in capacity-building should be based from the needs of the community; (3) an Inter-agencies collaboration and coordination should be established in addressing all aspects of climate change related issues; and (4) the adoption of the proposed school-community partnership program for enhancing resilience to climate change in the different communities.

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RESEARCH ARTICLE 02

Agencies and Communities Participation in the Climate Change Programs

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JPAIR Multidisciplinary Research, 37

Original publication: 2019

Vol. 37 - July 2019
<https://doi.org/10.7719/jpair.v37i1.711>

Print ISSN 2012-3981
Online ISSN 2244-0445

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Originality: 99% • Grammar Check: 100% • Plagiarism: 1%



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ABSTRACT

Metro Naga is primarily composed of Naga City and its surrounding municipalities in the province of Camarines Sur. It is located within the heart of Bicol's largest river basin area and is considered as a flood-prone region. This provides challenges to the government agencies responsible for implementing climate change programs. The study utilized the descriptive-evaluative design of mixed method of research to evaluate the community participation in the current programs and campaigns for Disaster Risk Reduction Management (DRRM) and Climate Change Adaptation (CCA). Information was gathered through Structured questionnaires, guided interviews, and focus group discussions (FGDs) from the randomly selected respondents of the four (4) Municipalities of Metro Naga. Based on the findings of the study, community residents only participated "often" on the DRRM and CCA programs (= 2.94) and the problems encountered in its implementation were no access to effective and applicable disaster risk financing and insurance (90%) and lack of initiative from the community to rebuild and repair the houses/buildings destroyed by the disaster (28%). As a result, continuous campaigns on community involvement in disaster risk reduction and climate change adaptation should be established. The adoption of community-based disaster risk reduction management will give opportunities to the community residents to be equipped with the skills and knowledge needed to be adaptive and disaster resilient.

Keywords — Agencies Culture, Communities participation, Climate Change Programs, Philippines

INTRODUCTION

Shreds of evidence of climate change was already seen throughout the globe. Forest fires, melting of glaciers, drying of lands and increasing number of endangered species were just a few pieces of evidences of climate change observed (Levitus et al. 2017). Scientific evidence revealed that the warming of the Earth's surface and change of climate is unequivocal (Robinson & Monte, 2014). Intergovernmental Panel On Climate Change (IPCC) is the United Nation's body for assessing the science related to climate change. It has been the body that provides regular scientific assessments on climate change to guide policymakers in addressing climate change issues and problems. IPCC further discussed that the extent of climate change effects on individual regions vary depending on how would the community will mitigate or adapt to change. (Parry et al. & Ciaia et al.)

Indeed, fighting climate change provide a challenge not only with policymakers but also with the government. Responding and adapting to climate change should be acted upon by all the stakeholders involved (Bulkeley, 2013). Climate change adaptation is key to the creation of climate policy. In the study of the status of climate change adaptation in Africa and Asia, revealed that evidence of adaptation initiatives is limited to country's receiving fund in adapting to climate change. (Ford, Berrang-Ford, Bunce, McKay, Irwin & Pearce, 2015).

Cities play an active role in climate change. High-end industrial machinery and other contributors in polluting the environment were commonly present in the urban areas or cities. With these city government should formulate and implement policy on climate change adaptation. But according to the study of Araos et. Al,(2016) cities that were identified as extremely adaptors to climate change belong to low-income countries.

In the Philippines, climate change is an evident and an alarming subject because the issue is viewed not only as of the cause of property loss and casualties but also as a critical factor that would appraise the survival of the country (De Leon, E. G., & Pittock, J. 2017). The effects of climate change on agriculture, forestry, marine life, etc. will further encumber a country already reeling from a host of socio-economic problems (Mercer, 2010). To address this issue Department of Interior and Local Government (DILG) and all allied national government agencies are working together to ensure the Philippines is ready for the future. The DILG, in particular, sees to it that relevant policies and programs are propagated, instilled and implemented among all local government units in the country. RA 9729, otherwise known as Climate Change Act of 2009 and RA 10121, or the Philippine Disaster Risk Reduction Management Act both aim to instill in the public consciousness that meeting the challenges ahead demands organization, coordination and systematic responses at all levels of governance and community management. Various DRRM and CCA programs and projects were institutionalized. One of these is the project NOAH or the Nationwide Operational Assessment of Hazards of DOST. The program is the country's flagship disaster prevention and mitigation program. Project Noah was launched after the destructive tropical storm Sendong in December 2012 (Mateo, 2017).

On the local front, Metro Naga is composed of Naga City and its surrounding municipalities (Bombon, Calabanga, Camaligan, Canaman, Gainza, Magarao, Milaor, Minalabac, Pamplona, Pasacao, Pili and San Fernando) are visited constantly by about 20-22 destructive typhoons annually (MNDC, 2019). When these disasters strike, Metro Nagueños are highly affected because they heavily rely

on the government agencies' courses of action concerning its active involvement in climate change awareness efforts in Metro Naga and Camarines Sur.

Recently, the National Resilience Council was made to address the issues and concerns regarding the disaster resiliency of the country where Naga City is a part of. It is the role of the local government to implement the provisions of DRRM and CCA. In this study, the involvement and compliance of the local government units and government agencies were being evaluated.

Establishing resiliency is one way of mitigating the impacts of disasters with the help of Inter-local government units and agencies' commitment in the implementation of DRRM and CCA with the active participation of the local community, adverse impacts of natural hazards will be reduced. In general, the effectiveness of the implementation of DRRM and CCA will depend on the compliance and participation of the LGUs, GAs, and local communities.

This provides challenges to the heads of the communities. Furthermore, this collaboration will lead to the improvement of people's adaptation to climate risk. Through the help of barangay officials, government agencies, employees, and household communities, this study evaluated the level of compliance and participation of the stakeholders in DRRM and CCA in Metro Naga and the problems and issues in its implementation.

OBJECTIVES OF THE STUDY

This study evaluated the level of compliance in the implementation of DRRM and CCA programs, campaigns, and activities by the Local Government Units (LGUs) and Government Agencies in the current programs and campaigns in Metro Naga in 2018. Specifically, the study determined the level of participation of community residents in Climate Change Programs, and the problems encountered regarding its implementation by Government Agencies (GAs) and communities.

METHODOLOGY

Research Design

The study utilized a descriptive-evaluative design of mixed method of research (Creswell & Creswell, 2013). Two different methods were utilized to confirm, cross-validated, or corroborate findings in determining the level of compliance and participation of the local government units and government agencies in DRRM and CCA programs. The data and information of this study were collected from

the responses of randomly selected community residents, government agencies, and local government units of the selected towns in Metro Naga. Focus Group Discussion (FGDs) were also administered and selected individuals were chosen to provide inputs during this focus group discussion. The discussions were guided by the survey instrument to confine deliberations to necessary issues.

Research Site

The study was undertaken in four municipalities of Camarines Sur, Philippines namely: Canaman, Camaligan, Milaor and Pili. These four municipalities were chosen because these were identified as flood-prone areas in Camarines Sur and had high risk in environmental disasters.



Participants

The respondents of the study were from Canaman, Camaligan, Milaor and Pili. It is composed of household heads, community chairman and personnel of government agencies from the different barangays in Canaman, Camaligan, Milaor and Pili.

Instrumentation

The research instrument was crafted to answer the problems stated in this study. A set of the research instrument was prepared for the community residents and the government agencies (GAs). One hundred and twenty(120) respondents participated in the validation of the questionnaire. The trial respondents' responses were analyzed and its measure of reliability was determined. The validated questionnaire was then used to gather information and data. The questionnaire

was composed of four parts. It includes the profile of the respondents, level of compliance/participation in the implementation of DRRM and CCA programs, and the problems encountered in the implementation of the program.

The questionnaires were administered and retrieved personally by the researchers. All targeted respondents were informed about the purpose and importance of the study and that honest answers would serve well for the study. The validity of the instrument was achieved through pilot testing, institutional peer review and literature review. On each research questionnaire, respondents were informed of the purpose of the study and were also asked for their consent in answering the questionnaire and using the data gathered. They were also assured of their anonymity and privacy. The statistical treatment included tallying, tabular presentation and statistical computations using a five-point Likert scale and average weighted mean. Weighted mean was used in determining the average of the responses in each of the given questions. This was used to find a single value out of the different results and in interpreting the data about a given condition (Bluman, 2013).

Table 1. Likert Scale For Community Participation and Gas Compliance

Scale	Verbal Description
3.01-4.00	always
2.01-3.00	often
1.01-2.00	sometimes
0.50-1.00	never

Table 1 shows the scale to rate the community participation to the DRRM and CCA programs. The verbal description “always” is rated in between 3.01 and 4.00, “often” is 2.01-3.00, “sometimes” is 1.01 – 2.00 and “never” is 0.50 – 1.00.

RESULTS AND DISCUSSION

Metro Naga is constantly hit by about 20-22 tropical storms/typhoons annually that trigger landslides and widespread flooding in various towns of Metro Naga namely: Camaligan, Canaman, Milaor, and Pili were high-risk areas for flooding. Typhoons would usually hit the Bicol Region during the latter part of the year, starting in September.

Local Government and Agency Disaster Response

Recognizing the huge task of stakeholders of vulnerable the provisions of R.A. 7160 or the “Local Government Code” sections 16 and 24, in which the responsibility of the national government and local governments for disaster planning, must be strengthened. Hence, the DILG is tasked to “formulate plans, policies and programs which will meet local emergencies arising from natural disasters...” has embarked different programs to be implemented that aims to create disaster-resilient communities. (LCCAP, 2014).

In Camarines Sur, disaster risk reduction and climate change adaptation start with its governor, which is Governor Miguel Villafuerte. He is the one who directs the Provincial Disaster Risk Reduction Management Council (PDRRMC) to immediately convene all the Municipal Disaster Risk Reduction Management Officers (MDRRMOs) and activate their respective incident management teams.

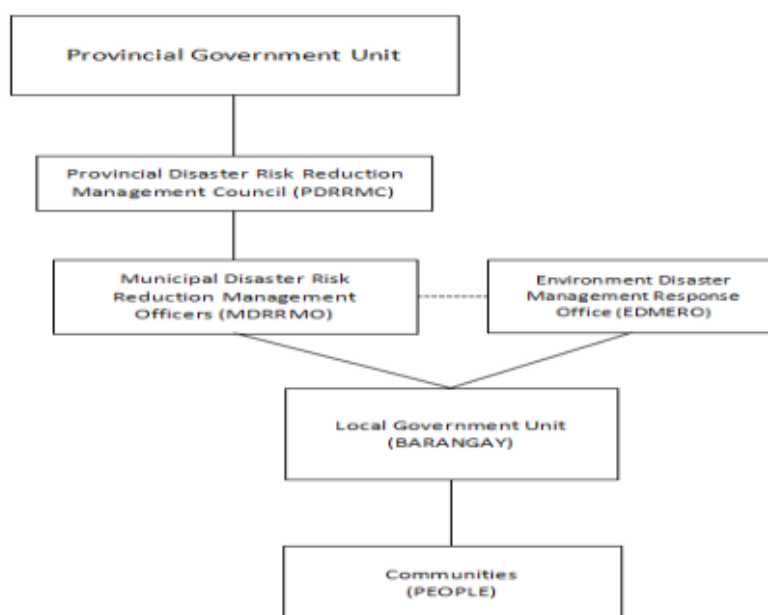


Figure 1. Local Disaster Response Framework

Every MDRRMO should have a well-prepared safety and emergency plan should a typhoon or any disaster strikes the province of Camarines Sur. Low-lying and flood-prone areas of the province were given special attention. The communication protocol was activated in all municipalities, alerting the chief executives and MDRRMOs to plan out the mobilization of its personnel to ensure that disaster protocols are in place. As part of the disaster protocols, emergency

ambulances are on a stand by mode as Camarines Sur PDRRMC preps up for typhoons. While Environment Disaster Management Response Office (EDMERO) help facilitate contingency activities and check on their barangay's vulnerabilities and risks so that preventive actions can be implemented.

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) bear the news about the weather conditions they also provide a warning to municipalities near rivers and streams tributary of the low lying area of municipalities of Camarines Sur which always includes Camaligan, Canaman, Milaor, and Pili. People living near the mountain slopes and low-lying areas are also advised to be alert for possible flash floods and landslides, and the local disaster risk reduction and management councils concerned are advised to be alert and take appropriate actions.

Compliance of Government Agencies (GAs)

Natural disasters strike unexpectedly and the only thing one could do is to alleviate the impact it will bring. Thus, the government puts an effort in developing a strategic plan to prevent and mitigate the adverse impacts of disasters (Ishiwatari, 2012). At the national level, the government aims to institutionalize and standardize DRRM measures and processes at the local and community levels; it seeks to empower the most vulnerable municipalities and cities in the country and to enable them to prepare disaster risk reduction and management and climate change adaptation programs, campaigns, and activities.

Table 2. Level of Compliance of GAs in the implementation of DRRM and CCA programs

Programs, Campaigns, and Activities	Mean	Description
Green technology for houses and buildings	1.85	Sometimes
Enhance communities' participation	2.31	Often
Collaborate with other community stakeholders	1.75	Sometimes
Well-established disaster response operations	3.01	Always
Safe and timely evacuation centers	3.52	Always
Basic services to affected communities	3	Often
Temporary shelters for affected communities	2.9	Often
Restore and strengthen economic activities	2.01	Often
Construct/reconstruct disaster and CC resilient infrastructure	2.3	Often
Programs on safety and rescue after each disaster.	3.7	Always
AVERAGE	2.63	Often

Table 2 presents the level of compliance of GAs in the implementation of DRRM and CCA programs. This gives a picture of how the GAs is implementing the programs on DRRM and CCA. It could be seen from the table that among the identified programs the following were rated as “always implemented”: programs on safety and rescue after each disaster (3.7); safe and timely evacuation(3.52) ; and well-established disaster response operations (3.01), while the program on green technology for houses and buildings with a mean of 1.85; and collaboration with other community stakeholders (1.75) or “sometimes implemented”. From the data, it clearly shows that collaboration with the different stakeholders is not yet established and only a few of the community members do. Overall the GAs compliance in the implementation of DRRM and CCA programs were rated “often” (2.63).

Communities Participation

Municipalities of Metro Naga, being one of the vulnerable municipalities in the country, have their own Municipal Disaster Risk Reduction and Management Council. These units strategize and integrate the Disaster Risk Reduction and Management and Climate Change Adaptation Plans for the community. Table 3 presents how often these programs are implemented at the community level.

Table 3. Communities Participation in DRRM and CCA Programs

Programs, Campaigns, and Activities	Mean	Description
Awareness on DRRM and CCA	2.31	Often
Well-established disaster response operations	3.01	Always
Integrated and coordinated Search, Rescue and Retrieval (SRR) capacity	3.25	Always
Evacuation of affected communities	3.52	Always
Basic social services	3	Often
Economic activities restored and strengthened	2.01	Often
Safer sites for housing	2.2	Often
Monitor for weather announcements/forecast	3.71	Always
Survival kits before the disaster strike.	3.5	Always
Adequate shelter needs	2.9	Often
AVERAGE	2.94	Often

From the data, it reveals that of the ten (10) identified programs participated by the communities, five (5) are rated as “always implemented.” Programs on monitoring of weather announcements or forecast (3.71); evacuation of affected communities (3.52); survival kits before the disaster strikes (3.5); integrated and coordinated search, rescue and retrieval capacity (3.25) and program on well-established disaster response operations (3.01). While the other programs such as awareness on DRRM and CCA, basic social services provided, safer sites for housing and economic activities restored and strengthened, and adequate shelter needs are rated as “often participated.” Overall the community participated in CCA and DRRM programs “often” (.

Problems Encountered

In the implementation of the program, government agencies encounter some hardship. Shown in table 4 is the five major problems encountered in implementing projects and programs on disaster risk reduction and climate change adaptation.

Table 4. Problems encountered by the Government Agencies (GAs)

Problems	Percentage
Lack of adequate shelter	50%
No comprehensive plans coming from LGUs	30%
No collaboration with other community stakeholders	80%
Basic social services are not provided	60%
No access to effective and applicable disaster risk financing and Insurance	90%

From the data, it could be seen that the highest problem encountered by the GAs during the implementation of the programs was: no collaboration with other community stakeholders (90%), no access to effective and applicable disaster risk insurance (80%), this is because the government does not provide micro-insurance or household earthquake or flood insurance for financial protection. Sixty-percent (60%) encountered the problems on basic social services; lack of adequate shelter (50%); and no comprehensive plans coming from LGUs (30%).

No collaboration with other community stakeholders may lead to the unsuccessful implementation of the program. Social services were also provided but not enough to answer the need of the community; thus, it is perceived as a problem by the government agencies implementing the program. Bicol is a natural disaster-

prone area must have access to effective and applicable disaster risk financing and insurance; however, it is limited to the individual who can afford it.

Table 5. Problems Encountered by the Communities

Problems	Percentage
Failure to follow policies and procedures	16%
Lack of participation in preparedness and response plan	18%
Lack of support from the LGUs	21%
Lack of initiative to rebuild and repair	28%
Lesser level of awareness	17%

From the data, it is shown that 28% of the respondents encountered the problem with lack of initiative of the GAs to help and repair the houses, 21% of the respondents identified that there is no support from the LGU, while 18% and 17% encountered the problems on lack of participation on preparedness and response plan and a lesser level of awareness, respectively. Only 16% encountered the problem of failure to follow policies and procedures.

The community seeks for support from different government agencies; thus they have perceived that one of the problems they have encountered is the lack of initiative from the GAs to help them rebuild the houses that had been destroyed by the typhoon, flooding or earthquakes. As to the lesser level of awareness, some part of the community was not invited to seminars, trainings, or workshops conducted by the government and other agencies.

CONCLUSIONS

Based from findings of the study, the following conclusions/implications are deduced: The community residents are “often” (2.94) participates in the Disaster Risk Reduction and Management and Climate Change Adaptation; with the local government efforts on implementing programs, campaigns, and activities. Twenty-eight percent (28%) identified that the community encountered problem in terms of lack of initiative to rebuild and repair properties destroyed by the disasters and 90% have no access to effective and applicable disaster risk financing and insurance.

Thus, it may be implied that: (1) implementation strategies of the Local Government should be revisited to strengthen the community involvement in the programs, campaigns, and activities of DRRM and CCA. (2) Disaster Risk

Reduction and Management (DRRM) and Climate Change Adaptation (CCA) plans should be anchored from the needs of the community and recognizing the existing coping mechanisms and capacities of the community/people as well as local know-how and resources is important to disaster risk reduction plans and strategies; (3) the adoption of community-based program for enhancing resilience to disaster and climate change.

TRANSLATIONAL RESEARCH

The findings of this study may be best translated to a pamphlet for information dissemination, if not, a further awareness campaign on climate change adaptation and disaster risk reduction. The pamphlet will have the information about climate change adaptation and disaster risk reduction management programs being implemented in Camarines Sur. These would be disseminated to different communities in the Philippines to give them an initial idea on what the programs are implemented is all about. The pamphlets can also serve as their initial guide if they want to venture in implementing programs in climate change adaptation and disaster risk reduction and management programs.

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RESEARCH ARTICLE 03

Self-Efficacy and Attitude towards Mathematics: Its Implication to Mathematics Learning

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Asia Pacific Journal of Social and Behavioral Sciences, 15

Original publication: 2018

Self-efficacy and Attitude towards Mathematics: Its Implication to Mathematics Learning

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Abstract

The study explored the implication of mathematics self-efficacy and attitude towards mathematics to mathematics learning. Specifically, it determined the relationship and effects of students' attitude towards mathematics (ATM) and mathematics self-efficacy (MSE) to students' mathematics performance. The study utilized the mixed method of research. The participants of the study were the 304 second year teacher education students to determine the causes, effects, and ways of overcoming negative ATM and low MSE. Results revealed that students' ATM and MSE were both significantly correlated and affect mathematics performance. The main cause of negative ATM was the teacher's behavior and pedagogy. The causes of low MSE were personal ability, fear of committing mistakes, and negative feedback from teachers. Students' negative ATM and low MSE resulted in students performing less in class. To overcome these challenges, teachers should treat seriously the need for improving the cognitive model among the students, because it influences their lives today and in the future. The result of the study revealed that teachers should not only teach students mathematical content but also help students manage their thoughts, emotions, and behavior positively towards mathematics because it has implication to mathematics learning. It can be done through teachers' careful curriculum planning, writing, and implementation with an appropriate supported curriculum that aims to develop positive ATM and high MSE among students. The students also need their parents' support through monitoring and checking their progress.

Keywords: Cognitive model, mathematics, learning, attitude, self-efficacy

Introduction

Mathematics is essential in all walks of life. It is fundamental in learning and vital to all levels of education. It is a very challenging subject to learn and appreciate, but its importance cannot be negated. In the curriculum of the Philippines' higher education institutions, mathematics is a

required general education subject. In an article Benzilin (2016) quoted that "life is a math equation. In order to gain the most of it, you have to know how to convert negative to positive." Being knowledgeable in mathematics is an advantage because according to her, mathematics is the cradle

of all creations, without which the world cannot move an inch. She added that human beings even living things are bound to learn and follow the laws of mathematics. Everybody needs mathematics in their day-to-day life. Be it a cook, a farmer, a carpenter, a mechanic, a shopkeeper, a doctor, an engineer, a scientist, a musician or a magician. Without mathematics, anyone will not be able to do science, architecture, geology, meteorology, or even a small enterprise. All of it requires the most basic prerequisite of life that is our ability to calculate, estimate, subtract or multiply. Hence, everyone needs mathematical training.

Moreover, Cadorna, Taban, and Gavino (2016) stated that the importance of mathematical skills could be seen in one's personal life and daily activities such as managing finances, marketing, handling business matters, payments, filing of income tax returns, and many more. In the article of Crockett (2016), he stressed that literacy is not enough. According to his survey, the consensus is that students need transparency-level skills for the 21st century. The 21st-century skills include mathematical literacy, critical thinking, creativity, and problem-solving. Reflecting on the message of President Aquino III to the 10th International Mathematics and Science Olympiad in 2013, he stated that "math and science are integral components of our path to progress, each subject allowing humankind to explore the limits of reality, and empowering us to shape the world with reason and imagination."

Congruent to it, Lee-Chua (2013) stated that the Philippines lags behind the rest of the world in Mathematics and Science expertise, as shown by Filipino student's dismal scores in global tests like the 2008 Trends in International Math and

Science Study. Chavez (2012) added that pupils have not mastered the competencies in concept formation, comprehension, computation, and problem-solving skills. In response, the Department of Education issued an order no. 31 s. of 2012, including the competencies on critical thinking, reasoning, and problem-solving skills of the students on the priorities of the Enhanced Basic Education Program through K to 12 Basic Education.

The studies of Klomegah (2007) and Nicolidau and Philippou (2008) revealed that students' positive attitude toward mathematics together with motivation and effort would increase performance. Numerous studies indicated that many children began schooling with a positive attitude toward mathematics (ATM); unfortunately these attitudes tend to become less positive as children grow up, and frequently become more pessimistic. Factors that may affect and have destroyed effect on ATM are the pressure exerted on the students to cope with highly demanding tasks, often a pace beyond their capabilities and ambition, together with unimaginable instruction and negative teacher attitudes. In addition, the high school years have been identified as a crucial period in the course of developing students' ATM. According to Nicolidau and Philippou (2008), teachers in high school have the opportunity and responsibility to promote and enhance students' positive attitude towards mathematics. Attitude towards mathematics (ATM) is associated with the psychosocial factor, the locus of control, defined as the personal belief about the extent to which one's behaviors affect or influence specific outcomes. Researches in mathematics education reform are driven by the belief that all students can learn. It is supported by the theory of Piaget under his information processing theory. This

theory contends that “children acquire skills through their everyday efforts to understand and master intellectual challenges.”

This attitude is reflected through their thoughts about mathematics. Yahya and Fasasi (2012) as cited by Cadorna (2016) reported that many students are not interested in the subject and these students do not possess a positive attitude towards the subject. They also stressed that these students are found to have a fear in the subject. This fear in math is a common problem that many people around the world have. Stephen's study (as cited in Yahya & Fasasi, 2012; also cited in Cadorna et al., 2016) emphasized that when a student is afraid of something, he will do everything to avoid it. Further, Fast et al. (2010) pointed out another factor that affects mathematics learning. The authors stated that the self-efficacy of the students towards mathematics is a strong predictor of math performance than either math anxiety or previous math experience. In general, self-efficacy in mathematics indicates the belief of a person in his/her own competence to solve math problems and achieve high math performance. To address this, Mcleod (2008) proposed in his study the use of CBT (Cognitive Behavioral Therapy). CBT is based on the ideas that how one thinks (cognition), how one feels (emotion) and how one acts (behavior) all interact together. He stressed out that specifically, thoughts determine one's feelings and behavior.

This study is deemed important not only to the teachers but also to the parents to know the effects of students' thoughts and belief on their behaviors. Student's behavior is reflected by his/her mathematics learning or performance. Findings on the effects of students' attitude towards

mathematics (ATM) and Mathematics' self-efficacy (MSE) to their mathematics' performance would pave the way for the teachers and parents to help the students overcome these challenges. The findings will also give teachers the opportunity to evaluate their teaching methodology and approaches whether these would develop a positive attitude of students towards mathematics or not. Moreover, these methods and approaches would be an avenue to help students develop self-efficacy in mathematics and avoid math anxiety. Since positive thoughts and beliefs are commonly developed during the early years in schooling, these should be treated well in the tertiary levels. As a response, this study investigated students' mathematics self-efficacy and attitude towards mathematics.

Theoretical-Conceptual Framework

The study is anchored on the cognitive theory of psychopathology of Beck (2011). He developed a comprehensive theoretical model called the cognitive model. This model describes how people's thoughts and perceptions influence their lives. It explains individuals' emotional, physiological, and behavioral responses as mediated by their perceptions of experience, which are influenced by their beliefs and characteristic ways of interacting with the world, as well as by their experience. In this study, cognitive model comprises the students' (1) attitude towards mathematics; and (2) self-efficacy in mathematics and its influence in mathematics performance. Students' attitude towards mathematics and mathematics self-efficacy describes how students' thoughts and perceptions influence their mathematics learning.

Nicolidau and Philippou (2008) stressed that thoughts or the attitude of the

students towards mathematics starts in the early years of schooling. They emphasized that the teachers in high school have the opportunity and responsibility to promote and even enhance positive attitude towards mathematics. They further explained that fostering positive attitude towards mathematics to students can influence their mathematics performance.

Bandura, in his expectancy theory (which is also known as valence, instrumentality, and expectancy), contends that an individual's effort will lead to performance, which in turn, will lead to a specific outcome (Bandura, 1986 as cited in Crothers et al., 2008). Students' thoughts reflected in their attitudes toward mathematics will lead to a specific outcome because of their actions. Having a positive attitude means that whatever happens there is something good that can be expected from it if efforts were exerted.

Smith et al. (2006) added that another factor that affects students' mathematics performance is math self-efficacy. Mathematics self-efficacy is based on an individual's belief about one's ability to perform specific behaviors. He said that "people with high self-efficacy are more likely to respond with renewed effort (expectancy) when feedback shows that they are not reaching their goals by developing more successful strategies." Supported by Hoffman and Schraw (2009), they said that "students with higher math self-efficacy persist longer on difficult math problems and are more accurate in math computations than those lower in mathematics self-efficacy." Liu and Koirala (2009) further explained that the higher a person rates on mathematics self-efficacy scales, the better this person performs in solving mathematical problems.

Self-efficacy theory of Bandura supports the study. It is based on an individual's belief about his/her ability to perform specific behaviors. Relevant to the statement of Smith et al. (2006), they affirmed that "people with high self-efficacy are more likely to respond with renewed effort when feedback shows that they are not reaching their goals by developing more successful strategies." Bandura added that in self-efficacy theory, people (students) perform the task in which they believe they can succeed; likewise, people are less likely to attempt tasks in which they perceive themselves less competent. He stressed that self-efficacy is the most influential predictor of human functioning. In this study, students' belief in their performance affects their behavior on how they will function in performing mathematics task.

Di Martino et al. (2010) found that there was an interaction with the three-dimensional model for attitude. They stressed that negative emotional dispositions towards mathematics might be associated with different patterns of attitude, depending on the students' perceived competence and vision of mathematics as well as on the relationship amongst the three dimensions. Further, they emphasized that the ATM of the student along emotional disposition must not only be considered as negative; hence when at least one of the dimensions is negative, students' negative attitude towards mathematics can be profiled depending on the dimension that appears negative. It means that the students' negative attitude starts with any of the three dimensions. To increase thoughts and beliefs about the subject, two of the earliest forms of cognitive behavioral therapy were (1) rational emotive behavior therapy developed by Ellis in the 1950's,

and (2) cognitive behavior therapy (CBT) developed by Beck in 1960's. The following therapy can be used by the teachers to help students with bad effects of negative attitude and beliefs toward mathematics.

This study is related to the studies aforementioned. However, it differs in some aspects. The studies of Nicolidau and Philippou (2008), Klomegah (2007), and Smith et al. (2006) all agreed that math performance is affected by the behavior of the learner towards mathematics. Hoffman and Schraw (2006), Fast et al. (2010), and Liu and Koiala (2009) are all in consensus as well that math self-efficacy is a strong predictor of mathematics performance. Phillips (2015) and Cadorna et al. (2016) both agreed that teachers could do a lot in helping the students overcome their fear of the subject. The methodology of this study is different from the previous studies in that it determined the influence of thoughts (ATM) and beliefs (MSE) on students' mathematics performance.

Objectives of the Study

The study aimed to determine the influence of students' attitude towards mathematics (ATM) and mathematics' self-efficacy (MSE) to students' mathematics performance. Specifically, it sought to determine the characteristics of the students along ATM and MSE; students' level of mathematics performance; the relationship and influence of students' ATM and MSE to mathematics performance; the causes of negative ATM and very low MSE; and ways in overcoming negative ATM and low MSE.

Research Methodology

The study utilized both quantitative and qualitative methods of research.

The quantitative method was employed to determine and describe the students' attitude towards mathematics and mathematics self-efficacy through the use of a questionnaire. This same method was utilized to determine the relationship and influence of students' attitude towards mathematics and mathematics self-efficacy to mathematics performance. The qualitative research method was employed through the informal semi-structured interview and focus group discussion. The informal semi-structure interview was employed to 35 randomly selected students to get their experiences in mathematics. The interview with the students was done for two weeks. From the interview, the effects of their past behavior to their performance were also recorded. Another 10 students were asked to participate in the focus group discussion.

The respondents of the study were the 304 second-year college students who were randomly selected through ratio and proportionate sampling from the population of 1,262. The 304 respondents answered the ATM and MSE questionnaires during the first phase of the study. These were the students enrolled in teacher education course. For the second phase, 35 respondents were selected and interviewed and answered the semi-structured questions, and another 10 respondents were also identified and participated in the focus group discussion.

Finally, these 45 selected respondents who participated in the semi-structured interview and focus group discussion were requested to share their opinions, ideas, and suggestions on how to foster a positive ATM and high MSE to the students. For the validity and authenticity, they were personally interviewed after the FGD by the researchers for purposes of

corroboration, enhancement, verification, and to capture other answers that were not found in the notes. The study used the ATM and MSE questionnaires which were adapted, modified, and patterned from the questionnaires of Programme for International Student Assessment devised by previous studies (Bandura as cited by PISA, 2013; Martha, 2009; Ferla et al., 2009). Before the final utilization of the questionnaires, the researchers consulted the experts to ensure the effectiveness and validity of the questions. Also, the questionnaires were tried to 42 students to test the reliability of the questions. To establish its reliability, Cronbach alpha was computed and found excellent at 0.94 for ATM and good at 0.87 for MSE.

Data Collection Procedure

Research protocol was observed in data gathering. Specifically, the data collection followed two-phase process. First, the 304 2nd-year college students answered the ATM and MSE questionnaires. The second phase was the semi-structured interview where 35 students participated and 10 students in focus group discussion. The second phase was vital in the data collection procedure to ascertain the most common causes, effects, and ways of overcoming negative ATM and low MSE.

The researchers also asked the students how they were able to overcome the problem and what their parents should do to help them. The students' response during the interview were analyzed and interpreted. Hence, new ideas were given and it added to the discussion of the study. Personal interview with the teachers was also conducted for purposes of triangulation and in regard to the ways in overcoming negative ATM and very low MSE. Mathematics performance of

the students was reflected in the mean of their mathematics grades from their freshman year. It was collected through the cooperation of the registrar.

The ethical standard was observed in the study through confidentiality of the results of the scores. Before the data gathering, the researchers sought informed consent from the proper authorities and the respondents. Data gathered were kept confidential through coding anonymously the respondents.

Statistical Treatment of Data

The following statistical tools were utilized to analyze the data gathered in the study: frequency count and percentage, weighted mean, and rank. Pearson product-moment correlation coefficient was employed to determine the relation of ATM and MSE to mathematics performance.

The coefficient of determination was employed to determine the degree or weight of effects of ATM and MSE to mathematics performance. Multiple regression analysis was used to determine the combined effect of ATM and MSE to mathematics performance.

Results and Discussion

Characteristics of the Students on ATM and MSE

On ATM. Table 1 indicates that the students' ATM average weighted mean is 2.65 with verbal interpretation of Positive ATM. It means that students have positive attitude towards mathematics. It can be gleaned from the table that the students have positive ATM because they perceived mathematics as a very

Table 1. Characteristics of the Students on Attitude towards Mathematics (n=304)

Attitude towards Mathematics Indicators	Weighted Mean	Int.	Rank
Mathematics is very worthwhile and necessary subject.	3.22	P	1
I will strive to improve my performance in Math.	3.04	P	2
I am interested in the things I learn in Mathematics	2.89	P	3
I find time to study Mathematics.	2.71	P	4
I am looking forward to my Mathematics lesson.	2.64	P	5
I love Mathematics!	2.58	N	6.5
I have usually enjoyed studying Mathematics in school.	2.58	N	6.5
I do Mathematics because I enjoy it.	2.50	N	8
I would prefer to do an assignment in Math than to do an essay	2.49	N	9
When I hear the word Math, I feel excited for the subject	2.48	N	10.5
I like to solve new problems in Mathematics.	2.48	N	10.5
I enjoy problem solving in Mathematics.	2.45	N	12
Mathematics is one of my favorite subjects.	2.41	N	13
I enjoy reading about Mathematics.	2.37	N	14
I am happier in Mathematics class than in any other subject.	2.34	N	15
Average weighted mean	2.65	P	

Legend:

(HN) Highly Negative ATM = 1.00-1.59

(P) Positive ATM = 2.60-3.59

Int. – Interpretation

(N) Negative ATM = 1.60-2.59

(HP) Highly Positive ATM = 3.60-4.00

important subject because it will improve their performance and they are interested in learning the subject so, they find time to study mathematics and look forward to mathematics lesson. It means that the characteristics of the students in ATM were positive because they know that it is important in their field and most of all it is a required subject. Further, having perceived the subject as important, students strive to improve their mathematics performance. It is apparent that when students are interested in the topics, they will allocate time to study and look forward to the lessons. It further implies that students will strive to perform better in mathematics if they perceive mathematics as a worthwhile and necessary subject.

It also means that teachers and parents should let students understand that mathematics is a very important subject for them to learn and study. However, it

cannot be disregarded that the students have negative ATM. Table 1 also reflects that students are happier in other subjects compared to mathematics; have negative attitude in reading about mathematics; do not consider math as one of their favorite subjects; do not enjoy solving problems in mathematics; do not like to solve new problems in math; do not express excitement about the subject; would prefer essay writing rather than solving problems in math; do not like to study mathematics in school; and responded negatively to the statement of loving mathematics. It implies that even if they have the knowledge about the importance of mathematics to their future careers they still have negative ATM on the subject. It means that there are factors that affect their interests, desire to study, and love for the subject.

The result of the study confirmed the statement of Nicolidau and Philippou

(2008) that many children begin schooling with positive attitudes toward mathematics, but unfortunately, these attitudes tend to become less positive as they grow up, and frequently become more negative. They stressed that the factors that may affect and have a negative effect on ATM are pressure exerted on the students to cope with highly demanding tasks, often a pace beyond their capabilities and ambition, together with unimaginable instruction and negative attitude of the teachers. They agreed that mathematics teachers have the opportunity and responsibility of fostering and developing the students' positive attitudes toward mathematics.

On MSE. Table 2 indicates that the students' MSE average weighted mean is 2.77 with a verbal interpretation of High MSE. The respondents answered the questions indicating their belief or confidence in doing the tasks. It can be

gleaned from the table that the students have high MSE in solving simple algebraic linear equations, discounts, surface area, volume, and distances. It implies that the respondents displayed high MSE in doing tasks that are being done and taught from elementary up to first year mathematics. It means that students are much more confident in doing things when they are already familiar with it. It also means that the students are confident to solve mathematics tasks if they are related to their daily living and have practical applications; like discounts, interpreting graphs in the newspaper, knowing the number of tiles to be bought to cover the desired area, and determining distances.

Further, Table 2 reflects that as the tasks increase in complexity, students' MSE decreases. For example, students' MSE computing in linear equation was high, but when it came to computing the

Table 2. Characteristics of the Students on Mathematics Self-efficacy (n=304)

Mathematics Self-efficacy Indicators	Weighted		
	Mean	Int.	Rank
Compute for the value of x in the equation $2x - 2 = 20$.	2.94	H	1
Solving an equation like $3(x + 5) = (x + 9)2$	2.89	H	2
Calculate for the price of pants after a 50% off.	2.87	H	3
Understanding graphs presented in newspaper.	2.76	H	4
Calculate the volume of a cube given a side	2.74	H	5
Workout how long it would take to get from one place to another	2.73	H	6
Calculate how much cheaper a refrigerator after a 25% discount.	2.70	H	7.5
Determine the formula to be used in a given problem.	2.70	H	7.5
Calculate how many tiles you need to cover a floor	2.65	H	9
Compute for the distance of one place to another.	2.64	H	10
Compute for the price of commodity given the equation.	2.56	L	11
Calculate the side length of a triangle using trigo. functions	2.55	L	12
Calculate the covered difference of height by knowing the slope of the street.	2.49	L	13
Estimating whether a 3 meter long board can be transported in a jeepney.	2.44	L	14
Calculate the petrol consumption rate of a car.	2.39	L	15
Average weighted mean	2.77	H	

Legend: (VL) Very Low MSE = 1.00-1.59 (L) Low MSE = 1.60-2.59
(H) High MSE = 2.60-3.59 (VH) Very High MSE = 3.60-4.00

price of the commodity given the equation, the students' MSE is low. It means that they have less MSE in performing similar task with too much complex application of the mathematical concepts. It further means that the students tend to have low MSE when mathematical tasks were complex and imply that students had problems in their MSE even when they perceived that mathematics is a very important subject. Relevant to the statement of Di Martino and Zan (2010, p. 44) as cited by Pepin (2015), they said that students' perceived competence affects their attitude in doing the task presented. Perceived competence was reflected in their MSE. This finding is supported by Smith et al. (2006) who implied that students with high MSE are more likely to respond with renewed effort when feedback shows that they are not reaching their goals by developing more successful strategies.

Students' Level of Math Performance

Table 3 reflects the mathematics performance of the students. The mean was 2.14 with a standard deviation of 0.39. The performance level of the students was 86% with a descriptive rating of very satisfactory.

It can be inferred that the students performed very satisfactorily and responses were homogenous. It means that their performance rating was near each other since the standard deviation is less than three. It implies that they share the same characteristics or may be thoughts and beliefs about the subject. It can be noted that the students were performing in between proficiency and satisfactory. However, this study aims to find ways to elevate mathematics performance to proficiency or even high proficiency. Gauss

referred to mathematics as the "Queen of the Sciences" (as cited in CHED Memo. 17 s. 2007). Learning it, therefore, will pave ways for students to develop competences that can be facilitative of learning other subject matters like chemistry or physics. It is then the researchers' ultimate goal to find ways to improve mathematics performance.

Table 3. Students' Mathematics Performance

	N	Mean	SD	Performance Level	Descriptive Rating
Mathematics Performance	304	2.14	0.39	86%	Very Satisfactory

Legend: n - sample size SD - Standard deviation Very Satisfactory = 82 - 88

The Correlation and Influence of Students' ATM and MSE to Mathematics Performance

As shown in Table 4, the correlation of ATM and MSE to students' mathematics have a computed value of $r = .332$ and $.333$, respectively, both with a verbal interpretation of low correlation. Both have a coefficient of determination value of $r^2 = 11\%$. The p-value indicates that the correlations were both significant. It can be inferred that students' ATM and MSE are significantly correlated with students' mathematics performance. Even if the correlation is low, the coefficient of determination reflects that ATM and MSE are 11% accountable to the changes in the students' mathematics performance. It implies that 11/100 performance of students that involves mathematical tasks can be determined by their ATM or MSE. Pepin et al. (2015) explained that negative emotional disposition results to a dislike in mathematics, a low perceived competence (low MSE). It means that emotional disposition can be considered as ATM, saying I like/dislike has a relationship with the students' perceived competence as reflected in their MSE.

Table 4. Correlation of ATM and MSE to Mathematics Performance

	Pearson Product Moment Correlation Coefficient (r)		Sig. (2-tailed)		
			Interpretation	p-value	Interpretation
ATM vs. Mathematics Performance	0.332	11%	Low correlation	0.00	Significant
MSE vs. Mathematics Performance	0.333	11%	Low correlation	0.00	Significant
ATM and MSE vs. Mathematics Performance	0.369	13.5%	Low correlation	0.00	Significant

Legend: If p-value < 0.05 (Significant)

Further, Table 4 also shows that the combined effect of ATM and MSE to mathematics performance is 13.5%. It can be inferred that the effect of the combination of ATM and MSE is 2.5% higher than its effect separately. It implies that it is imperative to look for ways to avoid negative ATM and low MSE because it has a significant negative effect in mathematics performance.

Supported by Fast et al. (2010), they asserted that mathematics self-efficacy is a strong predictor of mathematics performance than either math anxiety or previous math experience. This is related to the statement of Lett and Nillas (2012) who stated that self-efficacy and performance have a reciprocal relationship; self-efficacy affects performance and performance affects self-efficacy. It means that when students continually perform less in math, there is a probability that these students will have low mathematics self-efficacy.

To support this, the following were the transcripts of some of the responses of the students during the focus group discussion and interview about the effects of ATM and MSE to mathematics. Note: FGD# refers to the student from the focus group discussion while ISS# refers to student from semi-structured interview.

Student FGD1: *I am not confident if the topic is about math and other subjects related to number would be affected. And I am also easily discouraged because of my lack of self-confidence.*

Student FGD4: *Because of my attitude in the subject, I am not able to concentrate on the lesson, and I'm not willing to study.*

Student FGD5: *When my attitude to mathematics becomes negative, I find it hard to understand mathematics, find it boring, and eventually get low grades.*

Student FGD9: *I had developed high mathematics self-efficacy when I was in elementary and high school, so the effects were I got high grades, gained self-confidence/trust and overcame my weakness.*

Student ISS33: *I have positive ATM and have high MSE because: (1) Our teacher always respond to some clarification from us; (2) our teacher always provides exciting and interesting learning process; (3) our teacher presents her lesson comprehensively and challenges her students through games.*

Based on the response of the students, negative ATM affects not only their grades in math but also their psychological belief/thoughts about math. Because negative ATM results to the students' unwillingness

to study and concentrate, other subjects that include numbers can also be affected. Student ISS33 added that effective teaching pedagogy gave him positive ATM and high MSE.

Causes of Negative ATM and Very Low MSE

Thirty-five (35) selected respondents were interviewed about the causes of having negative ATM and low MSE. The following were the transcripts of some of the responses of the students who had negative ATM and low MSE when asked about the causes of their negative ATM and low MSE.

Student ISS1: *I think the cause of my negative ATM is that I always think that it is hard and I never really put an effort to love mathematics.*

Student ISS2: *It started when I was in grade 1. Our teacher is an essentialist and very terror in math. She always pushes us to excel in Math since she is a mathematician. Every time we received a low score, she punished us and let us stand for the whole period. Since then mathematics has become a terrifying subject for me.*

Students ISS4: *It all started during my secondary years. I remember that I had difficulty in mathematics. It was because our mathematics teacher during that time didn't conduct classes. Our teacher would just give us an activity to answer.*

Students ISS5: *It started in secondary school because mathematics was getting hard for me and the teacher made it harder by discouraging us every time we couldn't get the right answer.*

Student ISS6: *I find it difficult to understand*

during secondary years because the teacher would just face/talk to the one who understood the topic during the period.

Student ISS20: *It was because our teacher didn't teach us well and didn't promote good teaching and learning process.*

Student ISS21: *I have negative ATM and low MSE because when I was in elementary, my teacher in mathematics got easily angry when we could not catch up with the correct answer. Then, when I was in high school, my mathematics teacher was so lazy and she always left us with seatwork without even discussing it.*

Student ISS27: *I have negative ATM because I think my teacher's instruction and how she discusses topics are not delivered well. So, up to now I am not confident to do math problems.*

Student ISS30: *I have negative ATM and low MSE because of the teacher. Some of our mathematics teachers have more knowledge in the sense that they just teach the students in a boastful manner. They make the students feel that they know everything without hearing the difficulties of the students with the subject.*

Student ISS32: *I started to hate mathematics because of how my teacher delivers the lesson. He delivers it without fun in it. I found it boring and eventually lost my interest. However, when I am in fourth high school, I started to love mathematics because our math teacher motivated us and engaged us in different activities. But again, in college, I hated math again because of our teacher. Teacher is the factor!*

Based from the responses of the respondents, the students had positive ATM and high MSE in the early years

of their schooling. But most of them developed negative ATM in the secondary level because of their teachers' behavior and pedagogy. Some of the bad behaviors of the teachers as stated by the students were being terror, absent, self-centered, lazy, and boastful. Nicolidau and Philippou (2008) confirmed this statement when they said that many children begin schooling with positive attitude towards mathematics but unfortunately, these attitudes tend to become less positive as they grow up, and frequently become more negative. He stressed that these factors have destructive effect on students' ATM. Hence, Mata et al. (2012) added that the teacher plays an important part in developing students' attitude towards mathematics. On the other hand, students' attitude is not only the teachers' responsibility. Study shows that students' vision about mathematics, effort exerted, level of intelligence, and emotional disposition also affect ATM.

The result of the study also confirmed the three-dimensional model for attitudes (TMA) as discussed by Di Martino (2016). This model takes explicitly into account the close relationship of the three dimensions – (1) emotional disposition towards mathematics (2) vision of mathematics, and (3) perceived competence. It means that aside from the teacher's behavior and pedagogy, the TMA model affects students' ATM as reflected by the answer of student SSI1 saying "I always think that it is hard and I never really put an effort to love mathematics." Further, self-efficacy in math is included in the TMA model. It belongs to the students' perceived competence. The result of the study also found that the causes of very low MSE among students were personal ability (perceived competence); fear of committing mistakes (emotion); and destructive feedback from teachers (teachers' behavior). Hence, in this study,

students' ATM and MSE have significant relationship ($r = 0.65$). Note that according to the respondents, negative ATM and low MSE commonly starts at elementary and secondary level. Finally, the cognitive model explains that how the students think (thoughts), how the students feel (emotion) and how the students act (behavior) all interact together and affect mathematics learning.

Ways in Overcoming Negative ATM and Low MSE

The study identified ways to overcome negative ATM and very low MSE. Below are some of the transcripts of the recommendations of the students for teachers, parents, and for themselves when asked about how to avoid/overcome negative ATM and low MSE.

To the teachers:

Student ISS10: *They should be mindful of their students not in just one aspect but also in all aspects of education. And also teachers should not discourage children.*

Student ISS2: *I don't want the future generations to have the same perspective in math like mine. I want them to enjoy the beauty of numbers and to have fun in solving mathematical equations. Thus, I recommend that teachers should have an excellent and creative training ground for math. Instead of scaring the students with the numbers, teachers should promote self-efficacy to the students toward mathematics.*

Student ISS25: *Teachers should provide various ways in teaching mathematics. Children should be trained early for them to be able to love mathematics and they will be practiced to be confident.*

Student ISS22: *Teachers teaching mathematics should provide reinforcement and they should encourage the students with the idea that mathematics is not that complex; instead it is a manageable subject as long as you have the willingness to learn.*

To the parents:

Student ISS5: *Let them study with you and review the lessons at home*

Student ISS6: *They should check the progress of their child.*

Student ISS10: *They should follow up their kid and have tutorials at home.*

Student ISS23: *Always support your children and follow up about what they do in school.*

To the students:

Student ISS7: *If there is difficulty in mathematics lesson, they should ask about it and if possible ask for a tutor.*

Student ISS10: *They should be cooperative and collaborative with their teachers for them to catch up with the lesson and gain more knowledge.*

Based from the respondents, in order for the students to overcome negative ATM and low MSE, teachers should: (1) help the students develop holistic learning; (2) help the students enjoy mathematics by having fun while learning; (3) provide students with various teaching methodology and approaches to train them and become confident through practice; (4) and also provide reinforcements and encouragements that mathematics is not complex but a manageable subject. Parents' roles are: (1) support, (2) monitor, and (3) check their student's progress. The

students' roles are: study, ask questions, cooperate and collaborate with their teachers, and ask for a tutor when needed.

Teachers have different ways to approach and overcome negative ATM and MSE as indicated above. They can use the cognitive behavioral therapy by Beck (1960) or the rational emotive behavioral therapy by Ellis (1950) to help students become rational in their thoughts about the subject. However, it must be noted that verbal persuasions have a more limited impact on students' self-efficacy since outcomes are described and not directly experienced (Pantziara, 2016). It means that teachers should not only try to solve these challenges by verbal persuasions but also through developing didactical interventions. There are a lot of didactical interventions that a teacher can devise but the very important thing to consider in planning and making these interventions is to put the teacher's, parent's, and student's role in the teaching and learning process. One of the best ways to achieve this collaboration is through instructional materials being prepared by the teachers. It can be in a form of strategized instructional materials, modules, lesson plans, and even textbooks prepared by the teacher specifically for their students. These must be properly designed with qualities that promote positive attitude towards mathematics and develop students' mathematics self-efficacy.

To give an example, one of the researchers of this present study designed a sample text book that contains qualities of promoting positive ATM and high MSE. The textbook is entitled Mathematics 9: An Innovative Approach (ISBN: 978-621-802-332-1). It was carefully designed and developed by the researcher to help students develop positive ATM and high

MSE. A grade 9 student said that “When I started to use the text book, I came to love mathematics; it was just like playing a puzzle game. I just need to focus and enjoy every pace of the game.”

Dr. Josephine Francia Rivero-Villanueva, Dean of Graduate Studies, Naga College Foundation, Inc. commented: “The presentation of the lesson is done in a very conversational tone, as if the author is conducting a one-on-one tutorial to whoever will use the book; it is unhurried, devoid of pressure compared to some traditional textbooks which seems to rush the students from one task to another. The use of “Filipino” or “Tagalog” in some discussions will surely shed light and make learning the content easier, as compared to lessons purely articulated in English. Students will find this book interesting as well as informative in a relaxed and “no pressure” style. After all, learning happens in a relaxed and devoid of pressure learning environment.” This study does not claim that an instructional material has to be translated to Filipino for students to understand math. The point is the teacher should try to assess and determine the weaknesses of the students, and from there, they will innovate the teaching and learning process by providing appropriate instructional materials. On the part of the students, the text book was designed to assist them in their studies with or without their teacher because topics were comprehensively presented with many examples suited to the learner’s ability and interest. Mathematics self-efficacy can also be developed by having good learning experience and achievement through worksheets at the end of the lessons. The parents will also be given the opportunity to help, monitor, and check their students’ learning by going over their students’

home works and accomplishments. To help students develop positive emotional disposition in mathematics, teachers must not forget to integrate values and reinforce ATM.

Conclusion

The study concludes that improving students’ attitude towards mathematics and mathematics self-efficacy affect mathematics learning. Even if the respondents’ mathematics performance level was very satisfactory and they were happy in other subjects, they do not enjoy solving new problems in mathematics, and do not love the subject. Students’ Attitude towards Mathematics (ATM) and Mathematics Self-efficacy (MSE) were significantly correlated with mathematics performance. The main cause of students’ ATM and MSE was the teachers’ behavior and pedagogy. To overcome negative ATM and low MSE, the students suggested that teachers should be mindful of their students not just in one aspect but also in all aspects of education; have an excellent and creative training ground for math and promote self-efficacy of the students towards mathematics; should provide various ways of teaching mathematics; and should provide reinforcement and encourage the students to think that mathematics is a manageable subject.

Recommendation

Based on the findings, the following are highly recommended:

1. Teachers should help students manage their thoughts, emotions, and behavior positively towards mathematics. It can be done through teachers’ careful curriculum planning, writing, and

implementation with appropriate instructional material that aim to develop positive ATM and high MSE among students.

2. Teachers should help the students develop holistic learning; to enjoy mathematics by having fun while learning; provide students with various teaching methodology and approaches in training them to become confident through practice; and provide reinforcements and encouragement that mathematics is not complex but a manageable subject. Most importantly, teachers should not give destructive feedbacks.
3. Create/innovate instructional materials to encourage positive mathematics learning. Materials for both teachers and students must be carefully designed to suit the ability and potentials of the students. To achieve this, financial support from government and non-government organizations (NGOs) is needed.
4. Parents should support, monitor, and check their students' progress. Similarly, the students should focus on their study, ask questions to clarify concepts, cooperate, collaborate and ask for a tutor when needed. To achieve this, parent-teacher collaboration is needed.

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RESEARCH ARTICLE 04

Exploring the 21st Century Class Facilitation of Public Elementary Teachers

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Asia Pacific Journal of Educational Perspectives, 8(2), 40–48

Original publication: 2021

Exploring the 21st Century Class Facilitation of Public Elementary Teachers

Asia Pacific Journal of
Educational Perspectives
Vol. 8 No.2, 40-48
December 2021
ISSN: 2782-9332(Print)

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Date Received: May 17, 2021; Date Revised: December 15, 2021; Date Accepted: December 18, 2021

Abstract – This study determined the quality of the teacher's 21st century class facilitation along roles and as perceived in the classroom. Descriptive and comparative method to answer the research questions was employed. The respondents were the population of the three hundred and sixteen (316) grade 6 elementary pupils, nine (9) teachers, and six (6) school heads coming from six (6) elementary schools of one of the Divisions of Department of Education in the Philippines. Results revealed that the teachers' quality of 21st century class facilitation of being a leader, collaborator, and model was satisfactory, while of being an adaptor and communicator was fair. There is no significant difference on the quality of the teachers' 21st century class facilitation performance among roles while the students' perception differs with the perceptions of the teachers. Recommendations were that seminar – workshop and trainings should be provided to enhance teachers' communication skills and English proficiency, assist teachers to be able to adapt to the changing needs of the 21st century educational process. The school heads should make use of the teachers' quality of being collaborator, leader, and model to benefit the community and at least uplift young learners to study well, should develop an assessment tool to assess and monitor teachers' quality of class facilitation with an aim of helping teachers improve their class facilitation. Further, school heads should also conduct a formal mentoring with teachers, on-on-one interviews discussing ways to improve class facilitation and 21st century facilitators' characteristics. Proper frequent class monitoring is needed.

Keywords – 21st century, class facilitation, adaptor, collaborator, communicator, leader, model

Cite this article as:

Maravilla, M.F.O., & Repuya, C.R. (2021). Exploring the 21st Century Class Facilitation of Public Elementary Teachers, *Asia Pacific Journal of Educational Perspectives*, 8(2), 40-48.

INTRODUCTION

Education is a fundamental right of every individual, and it is a powerful tool for sustainable development. The world cannot escape hunger, end poverty, and improve nutrition without proper education. It is by which the world can become inclusive, equal, and peaceful. At its most basic level, education is vital to the society; because it gives people the baseline skills to survive in the world. These skills include basic literacy and numeracy, as well as the ability to communicate, complete tasks, and work with others. It also helps to contribute meaningful and quality life to build the nation as a competitive one.

To make this happen, teachers have the major role as the vehicle of education. For the teachers to become effective, competent, and productive, Republic Act No. 10533, SEC. 7 [1] stated that "to meet the demand for quality teachers and school leaders, the DepEd and the CHED, in collaboration with relevant partners in government, academe, industry, and nongovernmental organization, shall conduct teacher education and training programs, as specified: (a) in-service training on content and pedagogy, (b) training of new teachers, and (c) training of school leadership." Through this, every teacher will become not only efficient but also effective educators and facilitators of learning.

Today a lot of trainings and seminars are being conducted to improve and develop the craft of each mentor in school. Teachers must constantly seek to be better, both as an institution and as individuals. Stocks [2] stated that educators must be the agents of change. They must lead the professions. They must define what good teaching and learning looks like.

Teachers must ensure that all of them work together to meet the needs of the whole child. Teachers must also be student-centered union leaders and must play the long game. Teachers must passionately love their teaching profession to have a quality education particularly to elementary teachers. And if students are to be productive members of the 21st century workplace, they must move beyond the skills of 20th century and become master of those the 21st century. Teachers are entrusted with mastering these skills as well as with modeling these skills in the classroom. Hence, the characteristics of 21st century classroom will be different

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from those of the classroom in the past because the focus is on producing students who are highly productive, effective communicators, inventive thinkers, and Master of Technology. Richardson and Placier [3] emphasized that if teacher has better knowledge and skills, it improves classroom teaching. The study of Rossi, et al. [4]; Hiebert and Grouws [5], also said that the improved teaching raises student achievement.

Malik [6] stated that teaching-learning process is based on direct interaction between the students and the teacher. To perform this task effectively and efficiently the teacher needs to be proficient in interpersonal skills. Interpersonal skills involve effective communication skills to become comprehensible by the listener. Excellent at collaborative work when involve students in some practical work. Has command on her language and spoken style and is able of intellectually convincing arguments. He/she always uses his/her knowledge positively and wisely and above all respect's emotions of the students. Create a democratic atmosphere in the classroom. And effective teachers being an adaptor, the teachers liberate themselves from prescribed teaching materials and develop customized tasks for their students. They do not rely upon only the regular teaching methodologies rather they become self-sufficient in efficiently and effectively controlling and handling time to time changing situations.

Carvalho [7] explained that it is teacher-student interaction that makes students aware of their own ideas and gives them the opportunity to rehearse the use of a language that is appropriate for dealing with nature in a scientific manner.

The UNESCO 1996 emphasized that an effective teacher interacts with a child physically and mentally; she/he makes them learn what emotions are by being affectionate with them. She/he is responsible for overall personality development of the children. Their sound intellectual, emotional, physical, and social developments are the outcomes of her/his tremendous efforts throughout the teaching- learning process. A teacher is a complete person within; curious about her students' feelings, passionate, sociable, loveable and super comprehensive [8].

The Code of Ethics for Professional Teachers (1997) defined a professional teacher as a licensed professional who possesses dignity and reputation with high moral values as well as technical and professional competence [9]. In lieu of this, a teacher who is keen observer of these practices should become a good role model to the students.

Gabriel [10] explained the teacher leadership's uniqueness to command influence in a school and K-12 education. Teachers' leaders can choose from a variety of responsibilities which provide opportunities to have a role in improving school practices and functions, and in turn help students achieve. Churches and School [11] emphasized that teacher as leaders are that they are the subject experts, often a counselor and frequently an administrator. Merideth [12] added that teachers as a leader act like a REACH which

means risk-taking by seeking challenges and create new process, effectiveness by modeling best practice, professional growth, and heartfelt service, autonomy by displaying initiative, independent thought, and responsibility, collegiality by promoting community and interactive communication skills, and Honor by demonstrating integrity, honesty, and professional ethic.

Consequently, there is a need to investigate the actual manifestation of these 21st century facilitating characteristics as being an adaptor, Collaborator, Communicator, Leader, and Model, with an aim to make the teachers become better facilitators especially in elementary education. These 21st century characteristics were essential to the holistic development of students' learning skills. It clearly manifests that the students' holistic development of their learning skill must be developed as early in kindergarten and elementary education.

The holistic developments of students' learning skills may be dependent with the 21st century facilitators' characteristics or role manifested by their classroom performance as adaptor, collaborator, communicator, leader, and model since teachers are the facilitators of learning. By looking more closely to the teachers' 21st century facilitators characteristics and its actual manifestation inside the classroom as perceived by the teachers, school head, and most especially by the students, teachers and the institution can work together to improve teachers' facilitation and ensured that these characteristics are manifested inside the classroom.

OBJECTIVES OF THE STUDY

This study generally aimed to determine the quality of the teacher's 21st century class facilitation along roles and as perceived in the classroom. Specifically, it determined the quality of the teacher's 21st century facilitators along roles of being an adaptor, collaborator, communicator, leader, and model, and determined the difference among roles and its manifestation in the classroom as perceived by students, teachers, and school heads. Further, based on the findings, recommendations were made to improve quality and manifestation of class facilitation.

MATERIALS AND METHODS

Research Design

This study used the quantitative research design. Descriptive method was used to gather data and answer the research question about the quality of teachers' 21st century class facilitation along roles. And comparative method was used to compare each 21st century class facilitation roles and to compare the actual manifestation of the 21st century class facilitation in their classrooms as perceived by the students, teachers, and school heads.

Respondents

The respondents of the study were the population of the three hundred and sixteen (316) grade 6 elementary pupils, nine (9) teachers, and six (6) school heads coming from six

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(6) elementary schools of one of the Divisions of Department of Education in the Philippines.

Data Gathering Instruments

To measure the quality of class facilitation, a researcher-made questionnaire was designed based on the studies of Churches and School [11], Marideth [12], and Rossi, et al., [4]. The questionnaire on the quality of teachers' class facilitation was composed of 25-item questions equally divided to five (5) 21st century facilitators' roles namely, Teacher as (1) adaptor, (2) communicator, (3) collaborator, (4) model, and (5) leader. Each part is comprised of 5-item questions. The questionnaire was critique by the experts and educational leaders for content validity. The instrument was finalized after consideration of the suggestions, comments and recommendations given by the validators.

Data Gathering Procedure

A letter requesting to conduct of the study was prepared and given to the Schools Division Superintendent of the Department of Education and to the School supervisors for approval. Upon approval, the researchers worked on the preparation, construction, and validation of the research instrument. After the final revision of the questionnaires, data concerning the quality of the teachers' 21st century class facilitation were gathered through interview schedules with

the respondents to ensure reliability, validity and to avoid errors in answering.

Data Analysis

One-way ANOVA was employed to determine the differences between the 21st century class facilitation of the teachers as perceived by the students, teachers, and school heads.

Ethical Considerations

Respondents were informed that they were selected purposively as participants and informed consent from them through letter was secured by the researcher. The confidentiality of respondents' responses in the quality of teachers' 21st century class facilitation questionnaire was ensured.

RESULTS AND DISCUSSION

Quality of the Teachers' Class Facilitation

This study investigated the quality of teachers' class facilitation of the 21st century facilitators of learning as portrayed along roles as: Adaptor; Collaborator; Communicator; Leader; and Model.

Table 1 reflects results pertaining to teachers' quality of class facilitation along role as adaptor as perceived by teachers, school heads, and students.

Table 1. *Quality of the Teachers' Class Facilitation as Adaptor*

Indicators	Teachers	School Heads	Student	AWM	Interpretation	Rank
The facilitator is resourceful in preparing instructional materials.	3.66	3.83	3.14	3.54	Satisfactory	1
The facilitator ensures that each lesson will make authentic learning.	3.66	3.67	3.13	3.49	Satisfactory	2.5
The facilitator is able to make learning meaningful even with limited resources.	3.66	3.50	3.30	3.49	Satisfactory	2.5
The facilitator has used the computer platform in an effective way.	3.55	3.17	3.07	3.28	Fair	4
The facilitator has adjusted his/her lesson to meet the needs of the students.	3.44	2.83	3.06	3.11	Fair	5
Average Weighted Mean	3.59	3.40	3.14	3.37	Fair	

The teachers rated themselves highest in the facilitator is resourceful in preparing instructional materials, ensures that each lesson will make authentic learning, and able to make learning meaningful ($M = 3.66$) interpreted as satisfactory and lowest in the facilitator has adjusted his/her lesson to meet the needs of the students ($M = 3.44$) interpreted as fair.

The school heads, on the other hand, rated the teachers highest along the indicator such as the facilitator is resourceful in preparing instructional materials ($M = 3.83$) interpreted as satisfactory and lowest in the facilitator has adjusted his/her lesson to meet the needs of the students ($M = 2.83$) interpreted as fair. While the students rated the teachers highest in; the facilitator can make learning meaningful even with limited resources ($M = 3.30$) with

verbal interpretation of satisfactory and lowest in the facilitator has adjusted his/her lesson to meet the needs of the students ($M = 3.06$) interpreted as fair.

Overall, the facilitators' rating was highest in the facilitator is resourceful in preparing instructional materials ($M=3.54$) interpreted as satisfactory and lowest in the facilitator has adjusted his/her lesson to meet the needs of the students ($M=3.11$) interpreted as fair. Further, the data show that the facilitators' class facilitators as adaptor was rated highest by the teachers themselves ($AWM=3.59$) interpreted as satisfactory and lowest by the students ($AWM=3.14$) interpreted as fair.

The findings showed that the facilitators have satisfactory class facilitation along adaptor specifically in preparing instructional materials, ensures that each lesson

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will make authentic learning, and able to make meaning meaningful. However, facilitators need to improve in adjusting their lesson to meet the needs of the students. Further, both teacher and school heads agreed that the teachers' quality in class facilitation was satisfactory when it comes to being resourceful in preparing instructional materials to make authentic learning, in ensuring that each lesson will make learning a meaningful experience appropriate to students and make learning meaningful even with limited resources. However, according to the students, teachers' quality of class facilitation along these roles was fair and not satisfactory. It implies that the students disagree with the perceptions of the teachers and school heads. It means that for the students, teachers' class facilitation along these roles still needs improvement, because according to them it was just fair supported by the average weighted mean along these performances.

According to the teachers they perform these roles satisfactory, while according to school heads and students; it was only fair. It implies that school heads and students were not satisfied of the quality of teachers' class facilitation along these roles. It can be observed that as to the facilitators' adjusted his/her lesson to meet the needs of the students by using technology to cater different students' learning style, school heads rated lowest among the perceptions. It means that school heads were aware that teachers were not using satisfactory the technology in facilitating as also confirmed by the students. However, the results show that teachers were resourceful in preparing instructional materials to make learning authentic.

Further, among the aspects, the teachers were satisfactory in preparing instructional materials to make learning authentic while in contrast teachers are only fair in adjusting their lessons to meet needs. It means that teachers should improve in lesson adjustments to the needs and ability of the learners.

The results of the study were related to the study of Awolaju [13], he concluded that the role of instructional materials if thoroughly considered cannot be either partially or totally isolated from teaching-learning process. For any meaningful educational program to be achieved in terms of its implementation, the aspect of instructional materials must be given serious priority. Instructional materials perform such function as the extension of the range of experience available to learners, supplement and complement the teacher's verbal explanations. As a result, teachers as facilitators of learning as an adaptor reflect the 21st century skills in adapting to the needs of the learners to have meaningful learning experiences despite of lack of resources through creativity and innovations.

Table 2 reflects results pertaining to teachers' quality of class facilitation along role as collaborator as perceived by teachers, school heads, and students. The average weighted mean is 3.43 with verbal interpretation of Satisfactory. While the facilitator works collaboratively with the learners' parents about the learners' homework ranked lowest with mean 2.66, 3.17, and 3.24 as perceived by the teachers, school heads, and students, respectively. The average weighted mean is 3.02 with verbal interpretation of satisfactory.

Table 2. *Quality of the Teachers' Class Facilitation as Collaborator*

Indicators	Teachers	School Heads	Student	AWM	Interpretation	Rank
The facilitator has encouraged students to work together to accomplish tasks.	4.44	4.00	2.98	3.81	Satisfactory	1
The teacher is able to work hand in hand with the learners.	3.77	3.83	3.24	3.61	Satisfactory	2
The facilitator monitors, guides, and checks students' group projects and promote student works.	3.66	3.67	3.28	3.54	Satisfactory	3
The facilitator requires students to have group projects through collaboration.	3.44	3.00	3.17	3.20	Fair	4
The facilitator works collaboratively with the learners' parents about the learners' homework.	2.66	3.17	3.24	3.02	Fair	5
Average Weighted Mean	3.59	3.53	3.18	3.43	Satisfactory	

In general, the quality of class facilitation of teachers as collaborators as perceived by teachers and school heads was satisfactory with mean 3.59 and 3.53, respectively. While students only gave a fair rating in perceiving their teachers as collaborator, with mean of 3.18. On the average, the teachers' quality of class facilitation of being a collaborator was satisfactory with mean of 3.43. It means that teachers and school heads agreed that the quality of teachers' class facilitation as collaborator was satisfactorily along

performances such as encouraging students to work together in pair or in group, work hand in hand with learners, and monitoring, guiding, and checking students' group projects, and promoting it through student works' exhibit.

It can be inferred that the perception of students and school heads agreed that teachers required students to have group projects which can be accomplished through group participation and collaboration. It means that teachers sometime require project that cannot be accomplished

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collaboratively. And, when it comes to collaboration with parents about the learners' homework to be done and reporting of their progress, all agreed that it was fair. It also reflected that teacher rated themselves lowest among the perceptions about the collaboration with parents. It means that teachers have difficulty or challenges in working collaboratively with parents about learners' homework and progress, results were agreed by school heads and students. For example, when the teachers call for Homeroom PTA meetings or General PTA meetings where most of the parents cannot attend because some of them were busy nursing their children in their houses; some were working to provide the needs of their family; some has family issues and problems and most of them tend to let their eldest child to attend the meetings. By that parent know least about how their child progress in school or how their child

behaves in the school.

Supported by the study of Hernandez [14], he concluded that there's a need for students to see the intrinsic value of learning with others. They need to take responsibility for their own learning, which involves agreeing to take on different roles as part of the collaborative work, and planning and managing the group work from the start. Turning groups into effective collaborative teams may require "scaffolding" from teachers, so that they can support the students in achieving that goal. In this study, teachers were encouraging collaboration inside the classroom but need to improve on more collaboration with the students' parents.

Table 3. Quality of the Teachers' Class Facilitation as Communicator

Indicators	Teachers	School Heads	Student	AWM	Interpretation	Rank
The facilitator has communicated effectively in class and assists students.	3.66	3.50	3.28	3.48	Satisfactory	1
The facilitator listens carefully to the answers of students.	3.44	3.67	3.3	3.47	Satisfactory	2
The facilitator can clearly teach the lesson appropriate to the pace of the learners.	3.55	3.33	3.18	3.35	Fair	3
The facilitator displays good communication skills and teach lessons comprehensively.	3.33	3.33	3.16	3.27	Fair	4
The facilitator has been open to students' opinion and able to communicate using technologies or in any possible way.	3.55	2.83	3.15	3.18	Fair	5
Average Weighted Mean	3.50	3.33	3.21	3.35	Fair	

Table 3 reflects results pertaining to teachers' quality of class facilitation along role as communicator as perceived by teachers, school heads, and students. The facilitator has communicated effectively in class and assists students ranked highest with mean 3.66, 3.50, and 3.28 as perceived by the teachers, school heads, and students, respectively. The average weighted mean is 3.48 with verbal interpretation of Satisfactory. While as to the facilitators has been open to students' opinion and able to communicate with the students' using technologies ranked lowest with mean 3.55, 2.83, and 3.15 as perceived by the teachers, school heads, and students, respectively. The average weighted mean is 3.18 with verbal interpretation of Fair.

In general, the quality of class facilitation of teachers as communicators as perceived by teachers was satisfactory with mean 3.50. While students and school heads perceive teacher as a communicator fair with mean of 3.33 and 3.21, respectively. In average, the teachers' quality of class facilitation of being a communicator was fair with mean of 3.35 with verbal interpretation of fair.

It can be inferred that teachers and school heads agreed that teachers have communicated effectively in class and

assists students in doing their assigned task, and the teachers were listening carefully to the answers of students or when a student asked a question, he/she gracefully listens. It implies that teachers communicate well and listen. It can also be inferred that teacher cannot sometimes clearly teach the lesson appropriate to the pace of the learners' speed and convey the concept only as perceived by the students and school heads. It means that teachers need to consider the learners' pace and speed in learning concepts. It can also be inferred that teacher, school heads, and students, all agreed that teachers' performance in displaying good communication skills and teaching lessons comprehensively and being open to students' opinion and able to communicate with the students' using technologies were fair but not satisfactory.

It implies that teachers did not display satisfactory communication skills and teaching lessons comprehensively, as well as being open to the opinion of the students. It can be derived that teachers were misinterpreted by their pupils as not approachable one. From that, students avoid their teachers and not approach them anymore. In other way, facilitators become busy in everything that they do in making

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learning materials reports and lessons where pupils don't have any more chance to communicate with their teachers.

Relevant to the study of Khan et al [15], findings showed that majority of the students learned well from those teachers who has good communication skills or who adopt

good communication skills while dealing inside and out of the institution. They concluded that communication skills of a teacher having significant role in the academic success of the students. Therefore, it is necessary for a teacher to adopt good communication skills while teaching to the students.

Table 4. Quality of the Teachers' Class Facilitation as Leader

Indicators	Teachers	School Heads	Student	AWM	Interpretation	Rank
The facilitator shows enthusiasm in teaching students to instill values.	3.88	4.00	3.34	3.74	Satisfactory	1
The facilitator demonstrates knowledge in motivating students to perform and follow his/her instructions and programs.	3.88	3.83	3.25	3.66	Satisfactory	2
The facilitator has the courage to direct students to accomplish projects as planned.	3.77	3.67	3.24	3.56	Satisfactory	3
The facilitator teaches by example and lead students to learn what she teaches.	3.55	3.5	3.29	3.45	Satisfactory	4
The facilitator demonstrates decision-making skills to address concerns.	3.55	3.00	3.15	3.23	Fair	5
Average Weighted Mean	3.72	3.60	3.25	3.52	Satisfactory	

Table 4 reflects results pertaining to teachers' quality of class facilitation along role as leader as perceived by teachers, school heads, and students. The facilitator shows enthusiasm in teaching students to instill values such as being discipline and responsible ranked highest with mean 3.88, 4.00, and 3.34 as perceived by the teachers, school heads, and students, respectively. The average weighted mean is 3.74 with verbal interpretation of satisfactory. While as to the facilitator demonstrates decision-making skills to address concerns ranked lowest and school head and students both perceived it as fair with mean of 3.00 and 3.15, respectively. While teachers claim that they are satisfactory with mean 3.55. In general, the quality of class facilitation of teachers as leader as perceived by teachers and school heads was satisfactory with mean 3.72 and 3.60, respectively. While students perceive teacher as a leader fairly, with mean of 3.25. In

average, the teachers' quality of class facilitation of being a leader was satisfactory with mean of 3.52.

It means that according to the school heads and teachers, teachers were enthusiast in teaching, have demonstrates knowledge in motivating students, have courage to direct students to accomplish projects as planned, and teaches by example and lead students to learn what she/he teaches.

The result implies that teachers need to improve in decision-making skills as to address concerns of the students, parents, and other matters that will arise related to the learners' development and achievement. Supported by the result of the study of Richardson and Placier [16], they emphasized that if teacher has better knowledge and skills, it improves classroom teaching. The study of Rossi, et al. [4]; Hiebert and Grouws [17], also said that the improved teaching raises student achievement.

Table 5. Quality of the Teachers' Class Facilitation as Model

Indicators	Teachers	School Heads	Student	AWM	Interpretation	Rank
The facilitator demonstrates integrity, honesty, and professional ethic.	3.88	3.83	3.58	3.75	Satisfactory	1
The facilitator models best practice, professional growth, and heartfelt service.	3.77	3.83	3.35	3.65	Satisfactory	2
The facilitator displays initiative, independent thought, and responsibility	3.66	3.50	3.49	3.55	Satisfactory	3
The facilitator has the characteristics of being adventurous, seek challenges and create new processes	3.22	2.83	3.37	3.14	Fair	4
The facilitator promotes community and interactive communication skills.	3.11	2.83	3.31	3.08	Fair	5
Average Weighted Mean	3.52	3.36	3.42	3.43	Satisfactory	

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Table 5 reflects results pertaining to teachers' quality of class facilitation along role as perceived by teachers, school heads, and students.

The facilitator demonstrates integrity, honesty, and professional ethic ranked highest with mean 3.88, 3.83, and 3.58 as perceived by the teachers, school heads, and students, respectively. The average weighted mean is 3.75 with verbal interpretation of satisfactory. While as to the facilitators promotes community and interactive communication skills, it ranked last with mean 3.11, 2.83, and 3.31 as perceived by the teachers, school heads, and students, respectively, all with verbal interpretation of fair performance. The average weighted mean is 3.08 with verbal interpretation of satisfactory. In general, the quality of classroom performance of teachers as model as perceived by teachers, school heads, and students have a mean of 3.52, 3.36, and 3.42, with verbal interpretation of satisfactory, fair, and satisfactory, respectively. In average, the teachers' quality of classroom performance of being a model was satisfactory with mean of 3.43.

It can be inferred that teachers and school head agreed that teachers demonstrate integrity, honesty, and professional ethic and models best practice, professional growth, and heartfelt service to the learners. And all agreed that teachers display initiative, independent thought, and responsibility. It implies that teachers have satisfactory performance in displaying professionalism and values. It also implies that they adhered to the Code of Ethics for Professional Teachers, stated that a professional teacher is a licensed professional who possesses dignity and reputation with high moral values as well as technical and professional competence. So, a teacher who is keen observer of these practices should become a good role model to the students.

It can be inferred further that teachers need to improve in areas of performance in being adventurous and seek challenges and create new process. It means that teachers should find ways to innovate teaching for better learning and development of the students. Like for instance the activity

and learning materials that the facilitators already used in the past years was used again because they don't want to waste time anymore and they are used to it when they are teaching. Another example is when there is a field trip or educational tour most of the facilitators are afraid to risk going out because if there is an accident occur the facilitator are the one to shoulder the situation. And, teacher needs improvement in promoting the community, as a real role model of the students that is willing to serve the community and encourage students to do so.

Supported by Kim et al [18], in their study concluded that teachers' personality seems to be a promising path to identify factors important for vital aspects of teacher effectiveness. Students' perceptions of teacher conscientiousness, agreeableness, and neuroticism may be particularly useful in future considerations due to their association with a sense of being supported by their teachers, as well as their own performance self-efficacy. So, a teacher being a model was very important especially in facilitating learning.

Table 6 reflects the summary results for teachers' quality of classroom performance along roles as 21st century facilitators of learning. Teachers and School heads over-all rating was 3.58 and 3.44, both satisfactory, while students rating was 3.24 which means fair performance. Along the average weighted mean of the roles and responsibilities, being a leader ranked 1st with mean of 3.52 with verbal interpretation of satisfactory. It was followed by being collaborator and model both with mean 3.43 and verbal interpretation of satisfactory. Being adaptor ranked 4th among roles and responsibilities with mean of 3.37 and verbal interpretation of fair. The least among the roles was the teacher being a communicator with mean 3.35 with verbal interpretation of fair. On the average, the rating of teachers, school heads, and students along the roles was 3.42 which means, the quality of classroom performance along roles was of satisfactory performance.

Table 6. Summary Table for Quality of the Teachers' Class Facilitation

Roles	Teachers	School Heads	Student	AWM	Interpretation	Rank
Leader	3.72	3.60	3.25	3.52	Satisfactory	1
Collaborator	3.59	3.53	3.18	3.43	Satisfactory	2.5
Model	3.52	3.36	3.42	3.43	Satisfactory	2.5
Adaptor	3.59	3.40	3.14	3.37	Fair	4
Communicator	3.50	3.33	3.21	3.35	Fair	5
Over-all Average Weighted Mean	3.58	3.44	3.24	3.42	Satisfactory	
Interpretation	S	S	F	S		

It can be inferred that teachers were good at being a leader since they are in elementary level most of the teachers can possess leadership skills which allow them

to lead students to learning. Also, teachers were satisfactory at being collaborator and model. It can commendable since elementary teachers must work

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collaboratively with the students, parents and community to help learners develop social skills and also assist learners toward learning development (scaffolding). Since they are in elementary level which the students where children look for somebody to become their model, teachers become the students' model and inspirations in learning. It can also be noted that the performance along being adaptor and communicator was rated fair performance. It implies that teachers need to improve in these areas especially in communication since students and school heads agreed that teachers only perform fairly in communication. It is imperative since communication is the very important channel of learning and development.

The Differences on the Quality of Class Facilitation among roles and among respondents

Teachers as facilitator of learning of 21st century students must possess 21st century facilitators' characteristics. Table 7 shows the analysis of variance employed in determining the difference among aspects and among respondents (Groups). Table 7 reflects that the computed F-value among aspects was .699 and p-value of 0.595 with verbal interpretation of 'not significant'. It means that in general, there is no significant difference among aspects (roles). It also means that since these aspects or roles of teachers as 21st facilitators of learning are interrelated in enhancing students' learning experiences, the respondents perceived each role as important same with each other roles.

Table 7. *The Differences in Class Facilitation among Roles and among Respondents*

	Df	Mean Square	F	P-value
Aspects	4	0.069	0.699	0.595
Groups	2	0.763	7.750	0.001
Aspect*Groups	8	0.046	0.472	0.871

It implies that the 21st century facilitators' characteristics of the teachers do not significantly differ in general. It means that these characteristics were inter-related to each other in general that when a teacher possesses one of these characteristics, he/she may also have the other.

On the other hand, the computed F-value among respondents was 7.750 and p-value of 0.001 with verbal interpretation of significant. It means that in general there exists a significant difference among the responses of the respondents. It can be inferred that the perceptions of the respondents differ from each other as to the manifestation of teachers' roles as 21st century facilitators of learning. It is imperative to compute for the Post Hoc Test to determine where the significant differences occur specifically among respondents' perceptions.

Consequently, since Table 7 reflects that there exists a significant difference among the perception of the respondents about quality of class facilitation in 21st century facilitating along the roles, thus, table 8 reflects the Post Hoc Test result.

Table 8 reflects the results of the Post Hoc Test along the Class facilitation among respondents. It shows that the mean square of teacher vs school heads, and school heads vs. students of 0.1435 and 0.2040 with p-value of 0.278 and 0.079, respectively, both interpreted as not significant. It means that there is no difference on their perceptions. While in the teachers vs students, there exist a significant difference with mean of .3476 and p-value of .001. It means that there is no significant difference between the perception of the teachers and school heads, and between the school heads and students about the quality of teachers' classroom facilitation along roles as 21st century facilitators. It also implies that students' perception differs with the perceptions of the teachers.

Table 8. *Significant Difference in Class Facilitation among Respondents*

Pair of Groups	Mean Square	P-Value
Teachers vs School Heads	0.1435	0.278
Teachers vs Students	0.3476	0.001
School Heads vs Students	0.2040	0.079

It means that the school heads agreed to both the teachers and students' perception. In other words, school heads agreed with either students or teachers with regards to the roles which he/she perceived right. It implies that school heads perceived teachers' quality on class facilitation and at the same time agreed with the students as to its manifestation inside the classroom. It means that students' may have observed differently the quality of teachers' performance as manifested inside the classroom along roles as profess by the teachers that they possessed and manifested inside the classroom.

For example, as to teachers' has adjusted his/her lesson to meet the needs of the students by using technology both school heads and students perceived differently from the teachers' perceptions about these class facilitation along being adaptor. And while along being a leader, teachers and school heads agreed satisfactory with class facilitation of teachers, while students perceived these performances as manifested fairly inside the classroom. It implies that school heads perceived differently from teachers as to some roles, and also perceived differently from students as to some roles. It can be noted that students were the one who can validate it since they are always present inside the classroom while school head were not. However, maybe students are not able to determine those roles since they also are not aware about these roles. So, teachers must inform learners about their roles as teachers so that students will be able to understand their role inside the classroom, and what are the roles of their teachers.

However, it cannot be denied the fact of the possibility that what the teachers profess as their quality of 21st century facilitators of learning were not perceived by the students in the classroom. This means that the teachers should ensure that those roles be manifested inside the classrooms.

Zhang [19] in his study concluded that effective teaching behaviors mediate the relationship between teacher education and experience with student outcomes, indicating that teacher

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behaviors carry the most weight in terms of impacting those ultimate outcomes. The result of the study shows that teachers have the major role in making difference in what kind of learning experience will the students have inside the classroom. The success of providing good learning experiences comes from good 21st century facilitating skills mediated by teachers' behavior which are mainly perceived by the students.

CONCLUSION AND RECOMMENDATION

The teachers' quality of 21st century class facilitation of being a leader, collaborator, and model was satisfactory, while of being an adaptor and communicator was fair. There is no significant difference on the quality of the teachers' 21st century class facilitation performance among roles. Along the perceived manifestation of the quality of the teachers' 21st century class facilitation, there was no significant difference between the perception of the teachers and the school heads while the students' perception differs with the perceptions of the teachers.

Based from the findings, the following are highly recommended: With the help of the educational leaders, seminar –workshop and trainings should be provided to teachers to enhance teachers' communication skills and English proficiency. School heads should also assist teachers to be able to adapt to the changing needs of the 21st century educational process. It can be done by providing training to the teachers with topics on basic skills in ICT with specific use to 21st century facilitation of learning; The School heads should make use of the teachers' quality of being collaborator, leader, and model to benefit the community and at least uplift young learners to study well. It can be done by designing projects and programs aim to involve teachers, learners, parents, and the community.

School heads should develop an assessment tool to assess and monitor teachers' quality of class facilitation with an aim of helping teachers improve their class facilitation. On the other hand, school heads should also conduct a formal mentoring with teachers, on-on-one interviews discussing ways to improve class facilitation and 21st century facilitators' characteristics. Proper frequent class monitoring is needed.

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RESEARCH ARTICLE 05

Local Language Explanation-Infused Learning Material (LLE) and Activity-Based Formative Assessment (AFA): Enhancing Mathematics Learning

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Participatory Educational Research, 11(6), 242–261

Original publication: 2024



Participatory Educational Research (PER)
Vol.11(6), pp. 242-261, November 2024
Available online at <http://www.perjournal.com>
ISSN: 2148-6123
<http://dx.doi.org/10.17275/per.24.88.11.6>

Id: 1468767

Local Language Explanation-Infused Learning Material (LLE) and Activity-Based Formative Assessment (AFA): Enhancing Mathematics Learning

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Article history

Received:
15.04.2024

Received in revised form:
13.09.2024

Accepted:
24.10.2024

Key words:

local language explanation,
activity-based, mathematics
learning

The study employed mixed-method research, specifically a pre-experimental case study, to explore the influence of implementing local language explanation-infused learning material (LLE) and activity-based formative assessment (AFA) on mathematics learning. The t-test for dependent samples was used to analyze the influence of LLE and AFA on students' mathematics learning. Thematic analysis of the data from informal interviews, focus group discussions, and observations was used to support the findings. The participants were 38 Grade 9 students from one of the public secondary high schools in the Philippines, identified through purposive sampling and selection criteria. The findings showed that using LLE and AFA significantly improves mathematics learning along with illustrating, modeling, and problem-solving with small to medium effect sizes. The thematic analysis results show that the use of LLE is helpful for students to study independently because they find the lessons more straightforward to understand. The use of AFA helps students enjoy learning through individual and group activities, leading to the development of analytical and critical thinking. The study recommends integrating local languages into instructional materials, providing teacher training on LLE and AFA, ensuring resources of

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adequate sort for formative assessments, and strengthening monitoring mechanisms to enhance the implementation of these practices in the classroom.

Introduction

Achieving sustainable development goals (SDGs) requires a strong foundation in mathematics, which forms the basis of science, technology, and engineering. Despite spending \$236 billion annually on math education, the Organisation for Economic Co-operation and Development's (OECD) member nations still lack mathematical skilled talents (Fadel, 2014; Olaosebikan et al., 2022). Similarly, the Association of Southeast Asian Nations (ASEAN) countries also performed below the target mathematics performance except for Singapore, which ranked number one in the Program for International Student Assessment (PISA) 2022 results (Maamin et al., 2021).

The PISA 2022 results show that the mean performance in mathematics across OECD countries fell by a record 15 points between 2018 and 2022. PISA reports also show that 40% of the students reported that in most lessons, the teacher does not show interest in individual learning or does not continually teach until all students understand the topic in the material. Furthermore, 30% reported that in most or every mathematics lesson, students are getting distracted when using digital devices, and as a result, another 25% of students get distracted by other students who use digital devices in class (OECD, 2024a).

Investigating the data in PISA 2022 results using regression analysis shows that 56 out of 81 countries performed below the OECD average performance in reading, and 55 out of 81 countries performed below the OECD average performance in mathematics. As shown in Table 1, reading performance has a strong positive correlation with mathematics performance, $R = .935$, $p = .000$, interpreted as highly significant. Further, reading performance can predict mathematics performance, $R^2 = .874$, $F(1, 80) = 546.757$, $p = .000$, interpreted as highly significant.

Table 1 Regression Analysis of Reading and Mathematics PISA Result 2022

Predictors	R	R^2	Adjusted R^2	Standard Error	F	Sig.	f^2
(Constant) Reading	.935	.874	.872	20.058	546.757	.000	6.936

Dependent Variable: Mathematics

The value of R^2 shows the percentage of mathematics performance that can be explained by the performance in reading. This means that 87.4% of the changes in mathematics performance can be attributed to students' reading comprehension. Moreover, the effect size (Cohen's f^2) indicates that reading comprehension has a large effect on mathematics performance, with $f^2 = 6.936$. This implies that a country with high reading performance is expected to perform highly in mathematics. For example, Singapore scored 543 in reading and 575 in mathematics, ranking one in reading and mathematics. Countries with low reading performance will also have low mathematics performance, just like the Philippines, which scored 347 in reading and 355 in mathematics, which ranked 79th and 76th, respectively (OECD, 2024b).

PISA defines reading skills as the entirety of competencies that allow the reader to comprehend and apply the knowledge found in one or more texts provided for a specific



purpose (Sincer et al., 2024). Research findings show that reading comprehension significantly affects students' mathematics skills (Akin, 2022; Willcutt et al., 2013). Oral language skills, including phonological processing (LeFevre et al., 2010; Koponen et al., 2020; Vanbinst et al., 2020), vocabulary (Hornburg et al., 2018; Rinne et al., 2020), and listening comprehension (Willcutt et al., 2013; Wang et al., 2016) is also related to mathematics learning. Willcutt et al. (2013) stressed that verbal comprehension comprises vocabulary and comprehension and can explain difficulties in reading and mathematics. Sur and Ates (2022) found a significant relationship between reading comprehension and creative thinking skills. This means that the students in the Philippines are also expected to be low-performing in mathematics because they are low in reading. It implies that reading comprehension affects mathematics learning, and addressing reading comprehension and mathematics learning will benefit the students and enhance their performance in international examinations like PISA.

San Juan (2022) suggests using the Filipino language as a primary language for instruction instead of English in the Philippines. The researcher cited that the results of the National Achievements Tests (NAT) in School Year 2017-2018 and other international and local standardized tests show that many students lack competence in English in academic settings. But even though the students performed better in Filipino than in English, the government still imposed the use of English as a medium of instruction, which, as expected, will generally result in low performance in science and mathematics. Since some 94% of 15-year-old students in non-English speaking countries do not use English at home most of the time, the PISA allows countries to use non-English versions to convert the test to their local language. However, the Philippines used the English version of the PISA tests. In contrast, the East and Southeast Asia countries, and countries in the top 20 of PISA results in mathematics used non-English versions of the PISA tests, and all these countries outranked the Philippines. This means that since the countries used their local language in the PISA test, they have better reading comprehension, which contributes to the success of their students in the PISA 2022 results.

In addition, since PISA results reflect what the students have learned in the classroom, teachers are encouraged to use effective teaching and learning processes to respond to the students' different learning needs, considering reading and mathematical comprehension (Latanga, 2023). According to Godbout and Richard (2000), formative assessment is an integral part of the teaching and learning process, so teacher's assessment practices must be carefully planned to positively influence mathematics learning. Research findings show that formative assessment can positively affect students' mathematics learning (Andersson & Palm, 2017).

Further, the case studies of the Centre for Educational Research and Innovation (CERI, 2008) found that formative assessments contribute to high-performance outcomes by continuously monitoring student progress and understanding by providing ongoing feedback and adjusting instruction accordingly. The critical elements of the formative assessment that emerged were establishing a classroom culture that encourages interaction and use of assessment tools, establishing learning goals and monitoring individual learning progress, using differentiated instructional methods, using different approaches to assess student's learning, giving feedback on student learning, and most importantly, active involvement of the students in the learning process.

The related literature and studies highlighted the relationships between reading



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comprehension and mathematics learning and the use of formative assessments to achieve a high level of performance in mathematics. However, no investigations have focused on the combined influence of LLE and AFA in a classroom context. The LLE aims to facilitate understanding by infusing local language explanations into discussing mathematics topics in a conversational tone to ensure students comprehend the content efficiently and effectively. The objective of the AFA is to assess students for learning through active participation in activities where feedback is provided to guide students' learning process.

The study's results can benefit teachers, students, curriculum writers, educational leaders, and future researchers. The students will benefit from the learning materials infused with local language explanations and engaging activities developed as formative assessments. The teachers can also be guided by the results and be inspired to integrate local language explanations into mathematics learning materials and instruction and to design and implement activity-based formative assessments to foster a positive learning environment with engaged and participative students. The findings of the study can also enlighten curriculum writers on the importance of infusing local language explanation into the learning materials, especially in schools where English is seldom used. Educational leaders and researchers can be informed of the results of the present study and further investigate its effectiveness.

Hence, this study explored the influence of using local language explanation-infused learning material (LLE) and activity-based formative assessment (AFA) in teaching mathematics on students' mathematics learning. Specifically answered the following questions:

- (1) How can the local language explanation be infused into the learning material (LLE)?
- (2) What activities can be developed for the activity-based formative assessment (AFA)?
- (3) How does using LLE and AFA influence students' mathematics learning?
- (4) How does using LLE and AFA influence students' engagement and participation in mathematics learning activities?

Method

Research Design

The study employed a mixed-method research design, specifically, the pre-experimental case study research design (Creswell & Creswell, 2018), to answer the research questions, allowing the researchers to explore the influence of LLE and AFA on mathematics in depth both quantitatively and qualitatively, generating insights for further research. In the pre-experimental research design or one-group pretest-posttest research design, the pre-test provides a baseline measure of the outcome variable, which provides the initial level of performance of the students. After implementing the innovation (LLE and AFA), a post-test was administered to measure the outcome variable again. The qualitative part of the research design of the present study used thematic analysis from observational notes, interview responses, and FGD to provide additional strength and explain the effects of the LLE and AFA on the students' mathematics learning experiences (Saga et al., 2023).

Participants

Considering the research design employed by the study, which is the use of one group as participants, the selection process utilized a multi-stage approach. First, eligible criteria

were established. Initially, the group's mean score should be lower than the other groups. The group was purposively selected to participate in the study. Subsequently, students who had at least one absence during the research implementation were not included in the final participants reported in the study. Finally, the study participants were 38 Grade 9 students from one of the public secondary high schools in the Philippines. Further, Grade 9 students were selected because they are around 14 years old and will be the following students to take the PISA when they turn 15 years old (OECD, 2024a). Moreover, at this level, not all students have equal access to high-quality mathematics education, or the resources needed to succeed in learning mathematics (Sun, 2015).

Application Process & Data Collection Tools

The study adhered to all ethical requirements and protocols in data collection. After approval to proceed with the study by the school head and superintendent, the researchers prepare the data-collection tools for data gathering. Professional mathematics teachers in selected public secondary high schools in the Philippines validated the research instruments using the validation forms from the Department of Education (DepEd). The validators should be at least a licensed teacher, have at least five years of experience in teaching mathematics in public secondary high schools, and have a master's degree.

Before conducting the actual data-gathering method, the researcher-made test was first validated. After its revision, it was pilot-tested on 50 Grade 10 students in the same school. When the results are acquired, the pilot testing scores are subjected to item analysis to determine the final items to be included in the test. For the Index of difficulty, the waste item should have at least 0.21 and above the difficulty index to retain or revise. For the discrimination index, the item should have at least 0.20 and above to be included and considered a marginal or very good item (Navarro, Santos, & Corpuz, 2012). A final draft of a 24-item researcher-made mathematics pretest and posttest were created after 36 items were discarded during the item analysis, with a Cronbach alpha of 0.75 interpreted as acceptable. Then, the researchers conducted a student orientation for the participants to discuss the students', parents', and teacher's roles in the study. When the parents give their permission, and the students agree to participate, the informed consent for the parents, students, and teacher is signed.

During the implementation, the teacher and students used validated local language explanation-infused learning materials, which covered topics in quadratic equations, inequalities, and functions from the DepEd K-12 curriculum 2016. This was implemented over 10 weeks (see Table 2). The teacher gave the AFA at the end of each topic to encourage active engagement among students.



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Table 2 Topics, Activities, and Time Allotment

Topics	Activities	Week and time spent
Equations Transformable into Quadratic Equations	Solve equations that can be transformed into quadratic equations, including rational algebraic equations.	Weeks 1 & 2 (4 hours)
Solving Problems Involving Quadratic Equation	Solve problems involving quadratic and rational algebraic equations.	Weeks 2 & 3 (5 hours)
Quadratic Inequalities	Illustrate quadratic inequalities. Solve problems involving quadratic inequalities.	Weeks 4 & 5 (4 hours)
Quadratic Functions	Represent quadratic functions. Transform quadratic functions into the form $y = a(x - h)^2 + k$. Determine the domain, range, and graph of quadratic functions. Solve real-life problems involving quadratic functions.	Weeks 6 to 10 (11 hours)

Using the observation guide, an invited mathematics teacher from the same school served as the observer. The observation guide is a structured questionnaire that includes observations of students' mathematics performance, understanding, and participation. Additionally, it contains questions to identify learning experiences, challenges, and suggestions for improving activities related to the implementation of local language explanation (LLE) and activity-based formative assessment (AFA).

After implementing the LLE and AFA, the respondents answered the researcher-made mathematics posttest. Informal unstructured interviews and focus group discussions were also conducted after the implementation. The interview guide questionnaire was used to catch students' personal experiences using LLE and AFA. The students are given enough time to express themselves freely and think about their learning experiences. Finally, the focus group discussion (FGD) questionnaire was used to capture students' insights and learning experiences through oral and written responses. Focus Group Discussions (FGD) were conducted in small groups of 5-7 students after each lesson and at the end of the study's implementation. The observation guide questionnaire and FGD were validated for face and content validity.

Data Analysis

This study also utilized the Statistical Package for Social Science (SPSS) to analyze the data after it had been arranged in Microsoft Excel. The mean score was used to describe the data, and the percentage to describe the performance level. The performance level of the learning competencies was computed using the formula, $40 \text{ times (mean score divided by the total expected score)} + 60 = \text{PL}$ and was classified according to the mastery level set by the Department of Education (Albano, 2019), considering the descriptive equivalent of National Achievement Tests [NAT] scores, 35% and below (very low mastery), 36 – 65 (low mastery), 66 – 85 (average mastery), 86 – 95 (moving towards mastery), 96 – 100 (mastered).

The Shapiro-Wilk test was used to assess the data's normality and ascertain whether the data was suitable for the use of a parametric test. The students' pre-test scores in the researcher-made test were found to be normally distributed ($W = .975$, $p = .555$) and suited for using a parametric test. The paired t-test for dependent samples was employed to measure whether the observed differences in the pre-test and post-test mean scores in the researcher-made mathematics test were significant. Further, Cohen's index (d) was employed to measure the effect size of LLE and AFA on students' mathematics learning. The effect size was interpreted based on Cohen's standard and the new effect size (Sawilowsky, 2009; Serrano, 2018). The



Cohen's Index Interpretation was 2.00 (huge), 1.20 – 1.99 (very large), 0.80 – 1.19 (large), 0.50 – 0.79 (Medium), 0.20 – 0.49 (small), 0.01 – 0.19 (very small). On the other hand, thematic analysis using the teacher's observations, interview responses, and focus group discussion identifies students' learning experiences. Thematic analysis was used to interpret the qualitative data to provide insights into the students' learning experiences while using the LLE and exposed to AFA. Thematic analysis was employed to interpret the qualitative data, offering insights into students' learning experiences while using local language explanations (LLE) and engaging in activity-based formative assessments (AFA).

Results & Discussion

Local language explanation-infused learning material

This study first developed the textbook *Mathematics 9: An Innovative Approach* by Repuya (2017), published by Book on Demands Philippines. The foreword of the textbook explained that the book was an innovation that caters to the reading pleasures of the new generation. Table 3 and Figure 1 show how the local language explanation was infused into the lesson (italicized).

Table 3 Sample content in the local language explanation-infused learning materials

Lesson	Use of English	Use of local language (Filipino)
Quadratic Equation	Quadratic equation in which the highest-degree of the unknown quantity is of second degree of the exponent is 2.	<i>Ang pinakamataas na exponent ng literal number na "x" ay 2. Kaya ang tawag sa equation na ito ay quadratic equation.</i> [The highest exponent of the literal number "x" is 2. So this equation is called a quadratic equation.]
	Example: $x^2 + 8x + 16 = 0$ $2x^2 - 5x + 9 = 0$	
	The general form of the quadratic equation is $ax^2 + bx + c = 0$, where a, b and c are constants, and a is not equal to zero.	<i>Kaya sa quadratic equation na</i> [So, in this quadratic equation] $2x^2 - 5x + 9 = 0$, at [and] $a = 2$, $b = -5$, at [and] $c = 9$
Quadratic Function	It refers to a polynomial function having one or more variables in which the highest-degree is of second language.	<i>Kung ang arbitrary value ng x = 1, ang value ng y ay makukuha sa pamamagitan ng pagpalit ng 1 sa halip na x sa expression na $x^2 + 2x + 4$, dahil dito: $(1)^2 + 2(1) + 4 = 7$, kaya ang value ng y = 7. Sa paghahambing, kung ang arbitrary value ng x = 3, ang value ng y ay $(3)^2 + 2(3) + 4 = 19$</i> [If the arbitrary value of x = 1, the value of y is obtained by substituting 1 for x in the expression $x^2 + 2x + 4$, so: $(1)^2 + 2(1) + 4 = 7$, the value of y = 7. In comparison, if the arbitrary value of x = 3, the value of y is $(3)^2 + 2(3) + 4 = 19$.]
	Example: $y = x^2 + 2x + 4 = 0$	
	The value of y varies depending on the arbitrary values of x, and can be obtained by substituting said arbitrary values for x in the given function.	



Example 4

The total price of a certain commodity is given by the function $P(x) = x^2 + 8x + 16$. If x is the quantity produced, how much is the total price of the commodity if the company produced 5 items only?

Ang kabuuan na presyo ng kalakal ay $P(x) = x^2 + 8x + 16$. Kung ang value ng x ay ang dami ng nagawa, magkano ang kabuuan na presyo ng kalakal kung 5 items lang ang nagawa ng kumpanya?

Solution

If $x = 5$, then $P = (5)^2 + 8(5) + 16$

Thus, $P = 25 + 40 + 16$

$P = 81$ (The total price is Php. 81.00)

Figure 1. Sample problem with local language explanation.

The LLE presented like a Wattpad story wherein “Filipino-English” delivers the intended lesson without destroying the content. Students will think that the drills are mere games; the instructions and examples are articulated using the Filipino Language and presented in a very conversational tone.

The local language explanation was infused with the learning materials to highlight the mathematical concepts that should be remembered by the students. Further, local language explanations were infused with example problems to elaborate and ensure that the problem is understood. Mathematical terminologies are not translated into the Filipino language; they are explained in the Filipino language (the local language).

Developed Activities for the Activity-based formative assessments

Each AFA is a unique activity designed for a specific lesson. Activities available online and used by professional teachers to deliver their lessons are the inspiration for these learning activities. The activities were: (1) Quadratic Equations Activity Task Cards for lesson 1, (2) Quadratic Equations Puzzle Activity for lesson 2, (3) Domino Task for lesson 3, and (4) Quadratic Function Stationary Activity for lesson 4. Table 4 shows the list of the lessons and the corresponding activity title, materials used, and AFA instruction.

Table 4 Activity-based formative assessments

Lesson	Title	Materials	AFA Instruction
Lesson 1: Equation Transformable into Quadratic Equation	Quadratic Equations Activity Task Cards	Quadratic Equations Activity Task Cards (measures 3.5 by 2 inches and printed on a vellum board)	Each group must have a pen, an extra sheet of paper, and answer sheets. The facilitators will distribute the questionnaire containing quadratic equations. The goal of each group is to transform the given equation into its quadratic form and solve for the unknown variable. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they

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				may consult the facilitator.
Lesson 2: Solving Problems involving Quadratic Equation	Quadratic Equations Puzzle Activity	Puzzle Pieces (printed on a vellum board)		The facilitators will distribute each group's questionnaire of a unique quadratic equation or function-worded problems to each group. The group must brainstorm and answer the given problem to start the activity. After answering the problem, the group must present their answer to the facilitator for evaluation; if correct, the group may proceed to solve the following problem. Otherwise, they must re-answer the problem. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator.
Lesson 3: Quadratic Inequalities	Domino Task	Domino (made of chipboard)	Tiles of	Each group must have a pen, an extra sheet of paper, and answer sheets. The facilitators will distribute the domino tiles to each group. The group must select one domino tile at a time to start the activity. The group must work together to answer the given equation in each tile. After answering the given tile, the group must present their answer to the facilitator for evaluation; if correct, they may answer the next tile. Otherwise, they must re-answer the problem. When done, a group will share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator.
Lesson 4: Quadratic Functions	Quadratic Function Stationary Activity	Activity Task Cards (measures 3.5 by 2 inches and printed on a vellum board)		Each group must have a pen, an extra sheet of paper, and answer sheets. In this activity, there are 5 stations that you must visit. Your goal is to finish the journey. Each station has a problem that must be answered correctly before you can proceed to the next station. The facilitator will evaluate the answer of each group and will determine if they may proceed or not. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator.

In Lesson 1, focusing on Equation Transformable into Quadratic Equation, the activity is called Quadratic Equations Activity Task Cards (Figure 2), wherein the students can apply what they have acquired in the discussion by solving problems in a series of task cards. The class is divided into eight groups, with each group having at most 5 members (the same grouping is used for all activities). Then, each group was given cards (10 cards in each set) containing problems aligned with their topic. Each group is given 25 to 30 minutes to solve all the problems in their task cards. The cards measure 3.5 by 2 inches and are printed on a vellum board so that the quality of the material remains even after being distributed to the students compared to regular paper, which is easy to fold and crumple. After all the groups solved their task cards, the teacher asked them to present their work, explaining how they arrived at their answers, and allowed them to ask the teacher and their classmates if difficulties were encountered after the presentation.



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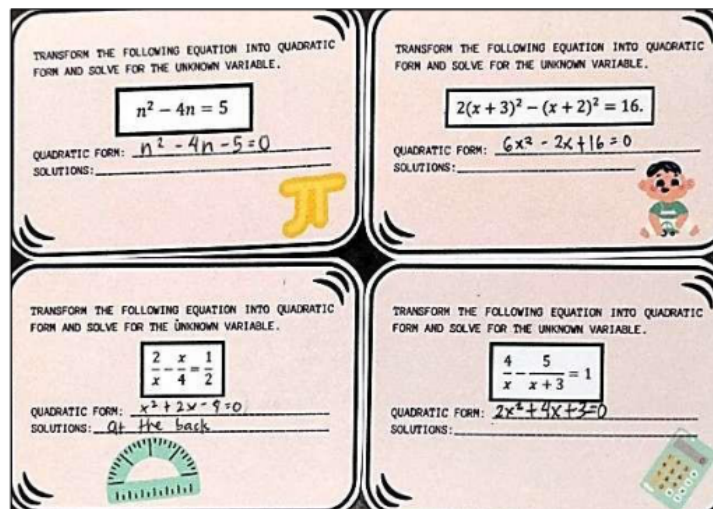


Figure 2. Quadratic Equation Task Cards Sample Activity

For lesson 2, the activity is called Quadratic Equations Puzzle Activity (Figure 3). For this activity, students solved the puzzle by answering the piece containing the questions. Each question has three other partner pieces that include the (1) transformed form of the worded problem, its (2) roots, and (3) standard form. The activity for lesson 2 has 20 puzzle pieces, equivalent to 5 questions. This activity is also based on speed and declares the winning group. In Lesson 3, the activity is called Domino Tiles Task (Figure 4). The students used modified domino tiles to apply their learning about quadratic inequalities after the cooperating teacher discussed the lesson. The groups are given five domino tiles containing the problems and the answers on both ends. The goal for this activity is to place the problem to the answer side by side until they are done placing them on their corresponding sides.

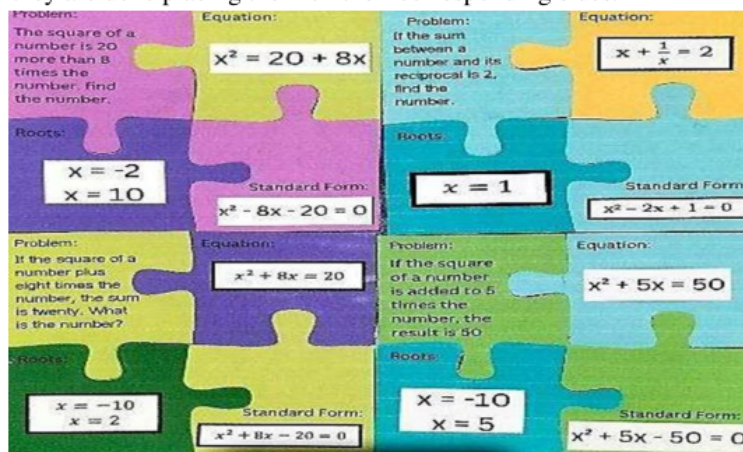


Figure 3. Quadratic Equation Puzzle Pieces Sample Activity

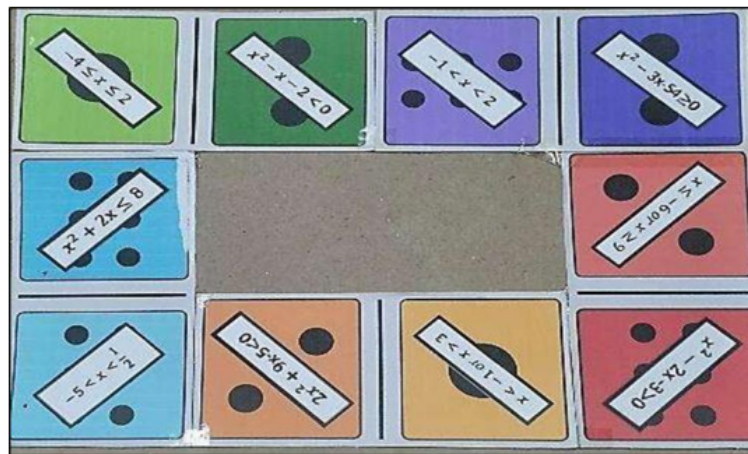


Figure 4. Domino Tiles Task Sample Activity

Finally, for lesson 4, the activity is entitled "Quadratic Function Stationary Activity." This activity has five stations containing one problem each and the students were given an activity sheet and fill it out as they solve each problem in every station. The task is to be completed within 50 minutes. The mathematical concepts involved in this activity are the axis of symmetry, maximum or minimum value, and vertex of a given function.

Influence of the use of LLE and AFA on students' mathematics learning

The participants of the study were from the low-performing class of the school, and the study was conducted to determine the influence of the use of LLE and AFA on students' mathematics learning. In this way, the study can explore the influence of LLE and AFA not only on students' cognitive skills but also on engagement and participation. The topics included are quadratic equations, inequalities, and functions. Three learning competencies were identified based on the curriculum of the Department of Education in the Philippines. Table 5 shows the pretest and posttest mean scores of the students in the researcher-made test.

Table 5 Results on the pretest and posttest researcher-made test

Learning Competencies	No. of items	Pre-test Mean	SD	PL	Int.	Post-test Mean	SD	PL	Int.
Illustrate quadratic function by graph	10	4.29	1.43	77.1%	A	5.79	1.97	83.1%	A
Model real-life situations using quadratic functions, and solve real-life problems involving quadratics	4	1.55	1.06	75.5%	A	2.05	1.03	80.5%	A
Over-all	24	10.66	2.53	77.8%	A	12.08	3.31	80.1%	A

Note. Table 5 shows the performance level of the students in the researcher-made test, which shows significant differences between pretests and posttests. The following is the abbreviation and corresponding meaning: *Int.* interpretation; *SD* standard deviation; *PL* performance level;



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A average mastery (66% – 85%).

In the pretest, the students' means score shows that the students have average mastery in illustrating, modeling, and solving real-life problems with performance levels of 77.1% and 75.5%, respectively. Overall, the students have a performance level of 77.8%, interpreted as average mastery. The standard deviation shows that the students' scores are homogenous. In the posttest, there was an observable increase in the performance levels of the students. The students' performance level increased by 6% from 77.1% to 83.1% in illustrating quadratic function by graph. In modeling real-life situations and solving real-life problems, the students' performance level increased by 5% from 75.5% to 80.5%. Overall, the students' performance level increased by 2.3% from 77.8% to 80.1%.

To determine if there was a significant difference between pretest and posttest performance levels of the students and the effect of the use of LLE and AFA on students' mathematics learning, table 6 shows the results of the paired-sample t-tests and the effect size.

Table 6 Results of paired-sample t-test on students' mathematics learning

Learning Competencies	Pre-test Mean	Post-test Mean	t-value	p-value	Int.	d	Int.
Illustrate quadratic function by graph	4.29	5.79	3.78	.001	S	.61	M
Model real-life situations using quadratic functions, and solve real-life problems involving quadratics	1.55	2.05	3.24	.003	S	.53	M
Over-all	10.66	12.08	2.43	.020	S	.39	S

Note. The following is the abbreviation and corresponding meaning: *Int.* interpretation; *S* significant ($p < 0.05$); *d* Cohens index; *S* small (0.20 – 0.49); *M* medium (0.50 – 0.79).

Along with the competency, illustrate the quadratic function by the graph, and there is a significant difference between the pretest and posttest scores, $t = 3.78$, $p = .001$. Cohen's index shows a medium effect, $d = .61$. The Result is similar along the competencies, model real-life situations using quadratic functions, and solve real-life problems involving quadratics, which also found the pretest and posttest to be significantly different, $t = 3.24$, $p = 0.003$. The effect size also shows a medium effect, $d = .53$. Overall, there is a significant difference between the pretest and posttest scores of the students, $t = 2.43$, $p = .020$. The effect size was found to be small, $d = .39$.

Results showed that the scores of the students in illustrating, modeling, and solving real-life problems significantly increased. This can be attributed to the use of LLE and AFA. In using the LLE learning materials, the students were able to comprehend the lessons because of the infusion of the local language to explain the concepts. While participating in the AFA, students were exposed to problem-solving activities where they could relate the concepts to concrete and then to real-life problems. It implies that the use of LLE and AFA can improve conceptual understanding in mathematics learning and help students practice problem-solving in more engaging ways.

The result of the study confirmed the statement of Ocampo and Del Rosario (2022) about translation-based instructional material in mathematics and that using translation-based

instructional material helps students improve their mathematics learning and talents in answering word problems. Additionally, using the LLE is related to Paz's (2017) study, which mentions that multilingual instruction in mathematics significantly contributes to students' performance.

Influence of the use of LLE and AFA on students' engagement and participation in mathematics learning activities

Thematic analysis was used to identify and interpret themes within the data from the interviews, journals, and FGD to answer the research question. The teacher's observation was also included in the discussion to confirm students' meaningful learning experiences. Table 7 shows the students' learning experiences on the use of LLE and AFA:

Table 7 Students' learning experiences on the use of LLE and AFA

Innovations	Students' learning experiences
Use of the Local Language Explanation-Infused learning materials (LLE)	Students find the lesson easier because of the use of Filipino-English instruction in mathematics.
Participation in the Activity-based Formative Assessments (AFA)	Students had fun experiences. Students show collaboration and teamwork. Students learn to think analytically.

Students find the lesson easier by using Filipino-English in mathematics

Results show that students found the lesson easier than before using the LLE. Student number 20 commends the LLE for having a Filipino explanation. Student number 19 finds it helpful in making the lesson easier because, in this way, students understand the topic's contents faster than the typical English presentation in regular books. Furthermore, Student number 16 explained that after being exposed to AFA, besides making the lesson easier, it also expanded their thinking capability [solving skills] because of the different exercises given under LLE. After introducing AFA, Student 19 finds the lesson much easier by mentioning that the topic is initially difficult but eventually becomes easy. Student number 27 found that participation is a varied experience by describing it as easy and challenging at the same time. Looking at the conclusion given by Student Number 27 explained that the overall experience was a success. Despite the hardship, the students can still solve the problems assigned to them.

The students' response to the interview questionnaire described their experience by giving positive feedback. The following are the students' interview entries about their thoughts and feelings toward the LLE and AFA:

S20: "Aside from its module [LLE] for understanding and knowledge, it has a Filipino explanation that made us understand it more."

S01: "I understand the lesson better."

S19: "I find it hard at first, but when I scanned more on the LLE, I find it a little easy."

S16: "Being exposed to LLE and AFA expanded my thinking capacity, allowing me to be more active in solving mathematical problems on the spot."



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S02: "It helps me."

S27: "I find it a little bit easier because the lesson is a bit hard, but we managed to solve it."

The response of the Teacher-Observer (TO) also verifies that students find the lesson easier. This is confirmed by the TO's answer to the question: Do you think the use of LLE and AFA helps the students understand the mathematics lesson? Why did you say so? The TO responds by saying, "Yes, the activities [LLE & AFA] help the students to understand the mathematics lesson better, especially equations that are transformable to quadratic equations. They tend to explore more of their understanding through activities". The TO also added her observation about the active participation of the students by answering the question: What did you observe about the student's performance in mathematics when exposed to LLE? How about their participation in mathematics lessons/activities? Saying, "Students were excited during the interventional learning activities. They were also keen in participating in the said activity".

In summary, from the responses given by the Teachers' Observer (TO) and students, it is observed that the students genuinely find the lessons easier after being exposed to the LLE and AFA. It is also evident that the active participation of the students shows their confidence, which is led by their clear understanding of the lesson. In this study, the feature of LLE of having a Filipino explanation is the key factor for making the lessons easier. This supports the study conducted by Siyang (2018), mentioning that using the mother tongue as a medium of instruction is more effective than using English. Using the language or dialect that the students are more familiar with helps them better understand the concepts in mathematics. Sometimes, language becomes a barrier to effective subject learning aside from difficulty and other factors.

Students had a fun experience

Activities conducted in the classroom help the students to have a fun experience and create excitement among them. The teacher must satisfy the students' positive emotions to ensure learning. Students who feel joy, excitement, and fun tend to learn more than their normal state. This is anchored to Maslow's Hierarchy of Needs in education, stating that "in order to succeed in the learning process, the student's basic needs need to be satisfied," which includes happiness (Alice in Methodologyland, 2020). Additionally, the study conducted by Ge (2021) supports the fun experience by stating that "positive emotions were associated with higher performance while negative emotions were associated with poorer performance and the low-intensity emotions were associated with performance between high and low levels."

Aside from learning the lessons in this study, students also had a fun experience engaging in AFA. Here is a sample of the student's interview responses that depicts their fun experience:

S20: "It is fun but also hard since the time is limited. I got the other answer wrong since I answered it a short time."

S23: "I'm happily conducting something like this, but it's really hard."

S37: "It is not all about solving quadratic formulas, but it helps us to enjoy more solving the puzzle."

S38: "It was fun and enjoyable. At the same time, we learned a lot."

From the statements, Student numbers 20 and 23 mentioned that students both have fun and

challenging experiences simultaneously. Difficulties experienced by the students in engaging in AFA are caused by other factors such as time allotment and lesson difficulty. Meanwhile, Students number 37 and 38 stated that the experience of engaging in AFA causes enjoyment for various reasons.

TO also agreed that students had a fun experience while exposed to AFA by confirming in the Teacher Observation Guide Questionnaire response. The TO answered the question, "Do you think the use of Interventional Learning Activities helps the students to understand the mathematics lesson? Why did you say so?" by saying, "Yes, the activity is a big help to them since they were able to explore more of quadratic inequalities in a fun and exciting way." Additionally, the TO also replied positively, showing the fun experience of the students by stating that "Students were actively engaged in the activity." They were excited about the new learning activity as they will experience a new game about Quadratic Inequality while being assessed for learning".

From the statements, it can be deduced that fun experience helps improve the students' mathematics learning. Having a fun experience leads the students to gain more learning compared to the knowledge they get from normal day-to-day engagement in class. It clearly shows that learning is effective when positive emotions are considered. It implies that teachers should implement activity-based assessment activities in the lesson, even before and/or after the discussion, to ensure learning, participation, and engagement. A group can do these activities or perform individually. Furthermore, activities are also suggested to create a fun experience among the students.

The results of the study are similar to the study conducted by Bavi (2018) about the effect of using fun activities on students' elementary-level learning. The study found that those students who were taught fun activities outperformed those taught the traditional way. The study implies that using fun activities to provide effective student learning shows significant results.

Students show collaboration and teamwork.

Cooperative learning happens when students work together in small groups to help each other comprehend a topic (Ridwan et al., 2022). Sometimes, learning with the help of others gives us a much better result since there is collaboration and more than one brain is working to solve a problem. Learning the lesson alone shows a different result than doing it with people to help. This is anchored to the collaborative learning theory, specifically to Vygotsky's social development theory, as cited by Erbil (2020). This learning theory argues that cognitive development is carried out via social interactions, and the learning process will continue more effectively due to interactions students engage in with peers who are more knowledgeable or adults. Results of the study show that students learned the sense of collaboration and teamwork after being exposed to AFA. The following are some of the entries of the students in the interview and FGD about their thoughts and feelings:

FGD1: We learned to socialize, and we understood better how to work together and cooperate with each other. We learned a lot.

FGD5: "It [AFA] helped us a lot, especially when we do groupings because it also serves as our study learning and exchange of knowledge."

S37: "There are groupings, and we can help each other better understand [Lesson on Quadratic Inequality]."



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S15: "I learn how to solve and participate in the group."

S13 & S38: "I learned how to cooperate well with the members and try to help them with the answers."

Groups 1 and 5 in FGD stated that students learned more while in groupings. The exchange of ideas and cooperation in a group provided by the activities introduced by AFA helped the students grasp the lesson even more. Students number 15 and 37 agree that because of AFA, students' sense of collaboration and teamwork grow with the understanding of the lesson.

The TO also agrees about the developed sense of collaboration and teamwork in students by responding to the question, "How do you think the use of ILA helps the students to understand the mathematics lesson? Why did you say so?" clearly stating that "The use of interventional learning activity helped them not just to understand better the lesson but also they learned that working together will lead them to the right results." Additionally, the TO quoted that during the implementation of LLE and AFA, she observed, "A strong sense of judgment (by oneself and by group) was developed during the activity. They could express their thoughts within the group, and with that, they could make the right judgment/conclusion to arrive at a correct answer".

From the responses, it was evident that collaboration and teamwork drills learning to students' minds. Teachers should be aware of the effect of collaboration and teamwork on students because this knowledge can help enrich the teaching and learning process. Additionally, student engagement can be improved when collaboration is utilized.

The result of the study implies that group activities in classrooms must be considered for students to learn effectively. Teachers can conduct activity-based formative assessments that can be done not only individually but by group. These group activities can also be differentiated so students can choose and be comfortable with their group mates (Answer, 2019; Zens, 2021). The study by Zens (2021) stated that differentiated activities impact student engagement and motivation in class. It also helps them to complete more of their work than those who do not undergo the intervention. Moreover, Anwer (2019) mentioned that activity-based learning is more interesting than lecture-based teaching and can improve students' academic achievement.

Students learned to think analytically and critically.

Through practice, analytical thinking may be stimulated and developed. It is one of the essential skills one must possess, which involves analysis, critiquing, and evaluating problems. The development of analytic thinking skills is anchored to analytic intelligence under Sternberg's Triarchic Theory (Montaku et al., 2012). The students learned to think analytically and critically after using LLE and participating in the AFAs.

The following are some of the statements of the students and Teacher Observer on the interview, Focus Group Discussion, and observation guide questionnaire:

S25: "In this lesson, I learned how to analyze more and understand how to turn the word problem given into an equation, getting the standard form and finding the roots."

S37: "In this lesson, we learned about combining or finding and analyzing the word problem in a short time."

S38: "I learned that you must first analyze the math problem to get the correct equation and roots."

From these, Students 25, 37, and 38 mentioned that because of LLE and AFA, they learned to analyze the question first to get the correct answer. The TO also verified the development of the student's critical thinking skills by answering, "What did you observe about the student's performance in mathematics when exposed to Interventional Learning Activities? How about their participation in mathematics lessons/activities?" The TO stated that "Students were excited during the interventional learning activities. They were also keen on participating in the said activity." The TO also quoted that on AFA, "The activity itself made the students more engaged in the topic, which is problem-solving on quadratic equations." Utilizing LLE and AFA helps students develop analytical and critical thinking skills. This complies with the conceptual framework of mathematics education in the Philippines, which emphasizes critical thinking and problem solving by putting them at the very heart of the curriculum (DepEd, 2016).

Conclusions and Recommendations

Based on the results, the study concludes that using local language explanation-infused learning materials (LLE) and activity-based formative assessment (AFA) in teaching mathematics can enhance students' mathematics learning, specifically along with the competencies such as illustrating, modeling, and problem-solving. The use of LLE is helpful for students to study independently because they find the lessons more straightforward to understand. The use of AFA helps students enjoy learning through individual and group activities, leading to the development of analytical and critical thinking. The following are the recommendations of this study:

- (1) Integration of local language in instructional materials and instruction to encourage independent learning and cultivate a positive learning environment.
- (2) Training opportunities for teachers on integrating LLE and AFA into their teaching and assessment practices.
- (3) Give teachers enough time and resources to develop activity-based formative assessments on their assigned subjects.
- (4) Strengthen mechanisms to monitor the implementation of formative assessments in the classroom.
- (5) Further research on the long-term effects of LLE and AFA into mathematics instructions employing quasi-experimental research design on a larger scope. In addition, investigate the effectiveness of the implemented innovation to explore any cultural or contextual factors influencing success and identify areas for improvement.

Limitations

Since the present study employed a pre-experimental design, numerous threats can affect the study's validity, such as regression to the mean (RTM), maturation of the subjects, history, and test effects (Marsden & Torgerson, 2012). Additionally, the researchers' involvement in the implementation of the activities further contributed to the study's limitations. However, the result of the study provides necessary preliminary investigation and valuable insights into the intervention's implementation and acceptability and to assess the feasibility and potential effectiveness of LLE and AFA to mathematics learning before conducting more extensive research involving larger samples and experiments (University of Michigan, 2019).



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RESEARCH ARTICLE 06

Predicting Licensure Examination for Teachers (LET) Outcomes: A Regression Analysis of Mathematics Teacher Graduates' Course Performance and LET Results

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Participatory Educational Research, 12(4), 151–167

Original publication: 2025



Participatory Educational Research (PER)
Vol.12(4), pp. 151-167, July 2025
Available online at <http://www.perjournal.com>
ISSN: 2148-6123
<http://dx.doi.org/10.17275/per.25.54.12.4>

Id: 1633200

Predicting Licensure Examination for Teachers (LET) Outcomes: A Regression Analysis of Mathematics Teacher Graduates' Course Performance and LET Results

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Article history	This study employed a predictive correlational design to investigate the extent to which the performance of mathematics teacher graduates in both professional and specialization courses predicts their outcomes in the Licensure Examination for Teachers (LET). Seventy-seven (77) respondents were identified through selection criteria and power analysis. The study's findings revealed that college course performance aligned with LET outcomes. Moreover, the results indicated a distinct emphasis on intellectual skills in general education and practical skills in professional education. Procedural fluency and problem-solving skills were highlighted in specialization, particularly in mathematics content courses. The study established a correlation between college course grades and LET performance, emphasizing the significance of specific courses. Recommendations include aligning instructional practices with LET competencies, enhancing curriculum emphasis, developing outcomes-based learning activities, introducing LET-type comprehensive examinations in general, professional, and specialization courses after 3rd year in the college to enhance retention and mentoring policies, implementing regression models for predictive analysis, and providing targeted professional development specially for teachers handling courses that are significant predictors of LET performance in professional and specialization, focusing on refining instructional practices and aligning them with the competencies emphasised in the LET. A confirmatory study is suggested to validate the identified causal relationships between the students' college course performance and LET performance and assess the effectiveness of the recommended regression models.
Received: 05.01.2025	
Received in revised form: 02.03.2025	
Accepted: 28.03.2025	
Key words: Licensure Examination for Teachers (LET), Mathematics graduates, Predictors, Professional Education, Specialization	

Introduction

The necessity for an adequate supply of competent and high-quality mathematics teachers is emphasized in the fourth Sustainable Development Goal of the United Nations to address the global problem of 60 percent of children not meeting the basic level of mathematics competency (United Nations Development Programme, 2024). As a significant determinant of student achievement, teachers should be competent enough to conduct effective teaching and learning (Kin et al., 2022).

The licensure examination is one of the methods used by other countries and the National to

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assess the abilities and proficiencies of teacher education graduates across all subject areas and their preparedness as entry requirements for the workforce following their college education (Yauney, 2022). But from 2010 to 2022, only 40% of examinees passed the exam in the National, according to a group of researchers from the Philippine Business Education (PBEd), and 56% of the schools that offered teacher education programs had below-average passing rates (Philippine Institute for Development Studies [PIDS], 2023). Specifically, only four out of ten (10) of the yearly supply of prospective mathematics secondary teachers were able to earn a license to teach, resulting in a shortage of licensed mathematics teachers who are Bachelor of Secondary Education Program (BSED) graduates (Aggabao, 2022). According to the PBEd executive director, Justine Raagas, poor performance in the LET puts teacher quality into question. Thus, before the possibility of the government discontinuing the educational programs of underperforming schools, raising the percentage of LET passers is the top priority of educational institutions for teachers in the National (PIDS, 2023).

Additionally, on April 27, 2022, Republic Act No. 11713 amended Republic Act No. 7784, an act that strengthened teacher education in the National by creating Centers of Excellence (COE), to intensify teacher education for excellence and establish scholarships for students enrolled in Philippine teacher education programs through the Teacher Education Council. The standards outlined in Section 5 of RA 11713 define COE and put special focus on the graduates' professional accomplishments and success in the government examination for teachers. The institution will benefit from being designated as a COE, particularly in terms of getting additional funding for its research and instructional activities (Teacher Education Council, 2022).

Along with the criteria to designate schools as COE was to be included in the ten top performing schools in the LET for three successive years, and for teacher education schools to be classified as high-performing, they must have LET passing rates of at least 75% (PIDS, 2023). Nonetheless, the study indicates that over 81 percent of institutions designated as (COE) did not achieve excellent performance on the licensure exam. As a result, it demonstrates the increased necessity for all teacher education programs to consistently find measures to raise LET performance to qualify or maintain COE status.

The quality of teacher preparation influences teachers' performance in the LET. The study of Abao et al. (2023), using descriptive-correlational method employing multiple regression analysis, found that graduates can perform better when they take the LET immediately after graduation. The extent of college preparation significantly affected LET performance, and the study highlighted that students' grades in college courses were significant predictors of passing the LET. The literature supported these findings (Bellen et. al., (2018); Balenario et al., 2023; Amanonce & Maramag, 2020). It suggests that when students get good grades, it means they did well on the coursework that the professors set, and as a result, they would do well on the LET.

Furthermore, based on the three-year data included in the study of Abao et al. (2023), the curricula of the BSED programs align with the standards of the Professional Regulation Commission (PRC). The recommendations were to review the weight distribution among the components of the LET, support the positive alignment between the curriculum, training for teachers, LET, and strengthen the curricular enhancement program of teacher education institutions to reinforce the input in general, professional, and specialised courses. Cadosales et al. (2023) stated that when course contents are carefully packaged with a focus on the intended results assessed in the licensure examination, there is depth in learning among



aspiring teachers.

In general, the BSED mathematics program has three components and corresponding weights in the LET: general education (20%), which is comprised of 10 courses; Professional Education (40%), which is comprised of 13 courses; and Specialization (40%) which is comprised of 21 courses. The graduates need a rating not below 50% in all three LET components and at least 75% overall rating (Commission on Higher Education [CHED] Memorandum No. 75, 2017; PRC, 2022). Considering the massive number of courses to be reviewed by the students before taking the LET, it implies a need to identify the specific courses among LET components with substantial weight. These courses can be focused on designing well-packaged content and activities. It means the curricular enhancement programs, such as enhancement classes and teachers' training, are more focused and tailored-fit with the expected outcomes measured in the LET.

Furthermore, it can also solve complex problems encountered by students after graduation, such as not being able to attend and enroll in review classes offered by the school for valid reasons because enhancement classes conducted before graduation may be enough (Malaluan, 2017).

The literature and studies highlight how crucial it is for students to fully prepare for the licensure exam. Such preparation should be aligned with the expected outcomes measured in the LET. The studies conducted in the National found that college course performance significantly predicted LET performance. However, little or none of the studies explicitly investigate which specific courses along each component are predictors of LET performance. Knowing the particular courses that are significant predictors of LET performance can guide teacher education institutions in developing, designing, and enhancing their programs particular to the needs of prospective teachers. Specifically, mathematics teacher graduates will be driven by the study's results by aligning their activities to give importance and focus to the courses that significantly impact future performance in the LET. Hence, this study was conducted to identify influential factors in Licensure Examination for Teachers (LET) performance mainly focusing on professional education and specialization courses that are significant predictors of LET performance of mathematics teacher graduates. As such, the study answered the following research questions:

- (1) What are the designated weights for general education, professional education, and specialization courses in the LET, as outlined in the PRC Table of Specifications?
- (2) What is the performance, as indicated by ratings, of BSEd majors in mathematics in the LET from 2018 to 2023?
- (3) Which specific Professional Education and Specialization Courses exhibit a significant relationship with LET ratings?
- (4) What regression model is recommended as a significant predictor of LET ratings in the specific domains of professional and specialization courses?

Method

Research Design

This study was pure quantitative research that used data from mathematics teacher graduates' LET performances and their college course performances. Predictive correlational design (Creswell & Creswell, 2018), was specifically used in the study to describe and

evaluate LET performances, find significant relationships between these performances and college course performances, and recommend a regression model as a significant predictor of LET ratings in professional education and specialization.

Participants

Collecting data from the entire population may not always be feasible due to challenges and constraints, such as accessibility, time, or cost. However, utilizing an appropriate sample size is considered acceptable and enables the derivation of valid conclusions from research findings (Memon et al., 2020). The selection process utilized a multi-stage approach. Initially, eligible criteria were established, focusing on mathematics teacher graduates from the years 2018-2023 who took the exam immediately after graduation and were first-takers. Subsequently, individuals meeting these criteria from a non-COE status state college/university in the National were invited to participate. The term non-COE refers to the schools who are not yet categorised as center of excellence by CHED.

Application Process & Data Collection Tools

The study adhered to all ethical requirements and protocols in data collection. The study used power analysis employing G-Power to determine the acceptable sample size of seventy-seven (77). The study included 77 respondents, chosen carefully based on the specific criteria. They were distributed as follows: 15 (19.48%) from 2018, 15 (19.48%) from 2019, 17 (22.08%) from 2020 & 2021 combined, 15 (19.48%) from 2022, and 15 (19.48%) from 2023. This selection, coupled with statistical tools used in the study, ensures a well-rounded and representative sample for the study.

Data regarding the LET ratings of the respondents were ethically obtained from the Professional Regulation Commission upon formal request facilitated by the office of the Vice-President for Academic Affairs of the college. In compliance with ethical standards, all participants agreed for the use of their LET ratings in this study. Furthermore, the grades of college courses were collected by the researcher with the explicit consent of the college department through the program chair.

Data Analysis

The Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the data after they were arranged in Microsoft Excel. All of the data were described using the mean and standard deviation and were numerical scores at the ratio level. The Shapiro-Wilk test was used to assess the normality of all the data to decide whether they were suitable for the subsequent parametric tests. LET ratings in general education are not normally distributed and negatively skewed since the median is greater than the mean which means that most mathematics teacher graduates perform well but a few of them perform poorly, this data is excluded for further parametric tests. The data on Professional Education ($M = 82$, $SD = 3.54$) and Specialization ($M = 86.40$, $SD = 3.49$) ratings were normally distributed ($p > 0.05$) and qualify for further parametric tests. The required number of samples considering the number of predictors was determined using G-Power. These results ascertain the assumptions for correlation and multiple regression analyses.

The correlation using Pearson product-moment correlation (r) was used to identify which specific professional education and specialization courses have significant correlation with LET ratings. In order to assess the predictive influence of the courses that demonstrated a



significant correlation with LET ratings, a comprehensive analysis was conducted using multiple regression analysis. The recommended regression models were recommended through careful considerations of the values of R^2 , adjusted R^2 , and the p-value. A higher R^2 shows better fit model and explanatory power and the adjusted R^2 account for the number of predictors in the model. Additionally, the p-value helps determine the significance of the overall regression model.

Results & Discussion

The designated weights for general education, professional education, and specialization courses in the LET, as outlined in the PRC Table of Specifications

A Table of Specifications (TOS) is a tool teachers can use to support their professional judgment when creating or selecting tests for use with their students (Fives & DiDonato, 2019). In the National, a TOS is a requirement in test construction. It uses Bloom's taxonomy to specify the level of learning. It indicates the learning competencies, number of items, and percentage of each item per competency, which is observed to be normally distributed to easy, moderate, and difficult questions. This study used the PRC-released enhanced TOS (PRC, 2022) last September 2022 to determine the weights of each component in the LET.

General education weighs 20% of the overall rating in the LET, with 150 items to be taken within two hours or 120 minutes. Three competencies are measured: intellectual competencies, personal and civic responsibilities, and practical skills development. The intellectual competencies include purposive communication in English, Communication using the national language, science and technology, and mathematics courses, which comprise 40% (60 items) of the general education tests. Another 30% (45 items) are from personal and civic responsibilities, which include readings in national history and society, the life and works of National Hero, and ethics courses. The remaining 30% (45 items) are from practical skills and development, including the contemporary world, art appreciation, and understanding the self-courses.

Based on the distribution of the items, greater weight is given to Science, English, and Mathematics courses. Based on the TOS of PRC, mathematics teacher graduates may have an advantage in mathematics; they need to master the skills and understanding or intellectual skills in English, Science, history, and the life of national hero courses.

In addition, professional education weighs 40% of the overall rating in the LET, with a total of 150 items to be taken within three hours or 180 minutes. Five competencies are measured: The teaching profession, the teacher and school curriculum, the child and adolescent learners and learning principles, assessment of learning, and field study and teaching internship. The teacher and school curriculum includes the teacher and school curriculum, methods and strategies for teaching, and educational technology courses, which comprise 30% (45 items) of the professional education test, which has the most significant weight among competencies in professional education. Followed by the child and adolescent learners and learning principles with courses specialised for toddlers, children, and adolescents (20% or 30 items), field study and teaching internship (20% or 30 items), and finally, the other 30% (45 items) was equally shared by the teaching profession and assessment of learning. It means that based on the TOS of the PRC, most of the items in the professional education test are from the courses related to the teacher and school curriculum, child and adolescent learners and learning principle, and practical skills developed from teaching internship. It implies that



mathematics teacher graduates need to give more weight to their reviews of these courses.

The remaining 40% of the overall rating in the LET is the specialization test to be taken within three and a half hours or 210 minutes with 120 items. Three competencies are measured: mathematical concepts and theories, problem-solving and processes, and principles and practices in teaching mathematics. Among the competencies, problem-solving and process have the most significant number of items, which comprise 63% (72 items), including college and advanced algebra, trigonometry, plane and solid geometry, logic and set theory, statistics and probability, analytic geometry, calculus, arithmetic number theory, and mathematics of investment. The other 23% (32 items) are from mathematics principles and practices, including strategies in teaching mathematics, assessment and evaluation in mathematics, research in mathematics, and the use of technology in mathematics teaching and learning. The remaining 14% (16 items) are from mathematical theories and concepts, which include the history of mathematics and mathematical investigation and modeling.

Based on the TOS of the PRC, it shows that more than half of the items were from the content courses in mathematics measuring procedural fluency and problem-solving. The teaching of mathematics and the history of mathematics also have a significant number of items in the LET. It implies that mathematics teacher graduates need to develop procedural fluency and master problem-solving skills in mathematics content courses, as well as mathematics teaching and learning processes and its history.

The performance of BSEd majors in mathematics in the LET from 2018 to 2023

The performance of the mathematics teacher graduates is measured through their ratings in the LET, as shown in Table 1. In general education, the Shapiro-Wilk result shows that the data is not normally distributed. It means that the median (91%) is greater than the mean. Hence, it is negatively skewed. Therefore, only fewer scores are less than the mean (85.40%) compared to the scores higher than the mean. 50% of the scores were higher than the median (interpreted as superior). Several scores were in between the mean (85.40%) and median (91%) and were interpreted as very good for some scores. Therefore, it is safe to say that the performance of the mathematics teacher graduates in general education tests was *Very good*.

Table 1. Performance of mathematics teacher graduates in the LET from 2018–2023

Components	N	Shapiro-Wilk	M	SD	Interpretation	Rank
		p-value				
General Education	77	.001	91.00	3.61	Very Good	1
Specialization	77	.074	86.40	3.49	Good	2
Professional Education	77	.474	82.00	3.54	Good	3
Overall Rating	77	.497	85.40	2.60	Good	

Note. Table 1 shows the performance of mathematics' teacher graduates in the LET 2018–2023. The following is the abbreviation and corresponding meaning: *n* sample size; *SD* standard deviation; if $p > 0.05$ normally distributed; *M* median for general education, *M* mean for specialization, professional education, and overall rating, For the interpretation: 76 – 80 fair, 81 – 86 good, 87 – 91 very good performance.

In specialization, Shapiro-Wilk results show that the data is normally distributed ($p > 0.05$). It shows that 50% of the scores fall between good and superior, while the other 50% were interpreted as good and fair scores. Since the median and the mean scores are almost equal, no clear outliers were found, and the mean ($M = 86.40$, $SD = 3.49$) as a measure of central



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tendency is safe to use. It means that the mathematics teacher graduates' performance in specialization was *good*.

The data in professional education also shows normal distribution ($p > 0.05$) and no clear outliers ($M = 82.00$, $SD = 3.54$). Hence, 50% of the scores were below 82.50; even though this was interpreted as *good*, it also shows that some of the scores were interpreted as *fair*. It means that mathematics teacher graduates struggle in professional education tests, and it is the possible reason why they fail or get low marks in the LET.

In the Overall rating, the Shapiro-Wilk results showed that the data is normally distributed ($p > 0.05$) with an overall mean score of 85.40 and a standard deviation of 2.60. 45.45% of the mathematics teacher graduates' performance falls below the mean, and the remaining 54.55% of the mathematics teacher graduates' performance falls above the mean. Specifically, seven or 9% of mathematics teacher graduates have a rating interpreted as *fair*, 29 or 28% of the mathematics teacher graduates have a rating equivalent to *good*, and 41 or 53% of mathematics teacher graduates included in the study have a rating interpreted as *very good*. It means that mathematics teacher graduates, in general, were very good in general education courses, and they were also good at their specialization. However, it can be noted that 32 out of 77 mathematics teacher graduates only performed fairly in the professional education test which resulted to the mathematics teacher graduates being lowest along professional education. It implies that they encounter difficulties in analysing and answering the questions or they are not prepared enough for the professional education test.

Comparing the LET performance of the mathematics teacher graduates to their college courses performance in professional education as shown in table 2, it can be noted that there is an alignment between the LET TOS of the PRC and the performance of the mathematics teacher graduates' courses performance. The mathematics teacher graduates performed lower than other courses in the teacher and school curriculum (rank 8) which comprise 30% of the LET questions, child and adolescent learners and learning principles (rank 5) and foundation of inclusive and special education (rank 7) which comprise 20% of the LET questions, and teaching profession (rank 6) which comprise the 15% of the LET questions. On the other hand, the mathematics teacher graduates performed *superior* in teaching internship and related courses (rank 1) which comprise 20% of the LET questions, and assessment in learning (rank 4) which comprise 15% of the LET questions. It shows that they performed well in the courses that have 35% weight in the total questions but not in the remaining 65% in the professional education.

Table 2. Performance of mathematics teacher graduates in the professional courses from 2018–2023

Professional Courses	<i>M</i>	<i>SD</i>	%	Interpretation	Rank
Practice Teaching (Teaching Internship)	1.32	.20	95	Superior	1
Technology in Teaching & Learning 1 (Educational Technology)	1.36	.27	94	Superior	2
Facilitating Learner-Centered Teaching (Facilitating Learning)	1.67	.29	91	Very Good	3
Assessment in Learning 1	1.71	.23	91	Very Good	4
The Child and Adolescent Learners and Learning Principle	1.76	.23	89	Very Good	5
The Teaching Profession	1.80	.25	89	Very Good	6
Foundation of Inclusive and Special Education	1.83	.29	89	Very Good	7
The Teacher and School Curriculum	1.94	.58	87	Very Good	8

Note. Table 2 shows the performance of mathematics' teacher graduates in professional courses in LET 2018-2023. The following is the abbreviation and corresponding meaning: *M* mean, % level of performance, 81 – 86 good, 87 – 91 very good, 92 – 96 superior, 1.00 highest grade.

In specialization, the LET performance of the mathematics teacher graduates is also aligned with their college courses performance. The graduates performed very good in the courses: advanced statistics (91%), technology in teaching and learning (90%), modern geometry (89%), probability and statistics (88%), mathematical investigation and modelling (87%), number theory (87%), and trigonometry (87%). However, even though interpreted as good performance, the mathematics graduates performed lower in the courses: college and advance algebra (86%), calculus 2 or Integral Calculus (85%), history of mathematics (84%), plane and solid geometry (82%), analytic geometry (82%), calculus 1 or differential calculus (82%), linear algebra (81%), and abstract algebra (81%). It can be noted that these courses comprise 63% or 72 out of 120 items in the specialization test under processes and problem-solving competencies. It means that mathematics teacher graduates need to improve more by mastering the skills in processes and problem-solving in these courses, especially in abstract algebra, linear algebra, and calculus, to increase their performance in the LET.

According to Agustyaningrun et al. (2021), the dominant factors that cause difficulties in learning mathematics, like abstract algebra, are students' attitudes, lack of prior knowledge, and inadequate teaching materials. Students' motivation, lecturer performance, and learning methods are also identified. It means that teacher education institutions can check the factors to determine the causes of these low performances.

Table 3. *Performance of mathematics teacher graduates in specialization courses from 2018–2023*

Mathematics Subjects	M	SD	%	Interpretation	Rank
Research in Mathematics Education	1.40	.46	93	Superior	1
Advanced Statistics	1.69	.45	91	Very Good	2
Technology in Teaching & Learning Mathematics	1.77	.42	90	Very Good	3
Modern Geometry	1.82	.36	89	Very Good	4
Probability and Statistics	1.87	.32	88	Very Good	5
Mathematical Investigation and Modelling	1.97	.42	87	Very Good	6
Number Theory	2.04	.53	87	Very Good	7.5
Trigonometry	2.04	.37	87	Very Good	7.5
College and Advanced Algebra	2.10	.46	86	Good	9
Calculus 2 (Integral Calculus)	2.22	.52	85	Good	10
History of Mathematics	2.24	.28	84	Good	11
Plane and Solid Geometry	2.42	.39	82	Good	12
Analytic Geometry	2.41	.37	82	Good	13
Calculus 1 (Differential Calculus)	2.42	.36	82	Good	14
Linear Algebra	2.47	.54	81	Good	15
Abstract Algebra	2.52	.41	81	Good	16

Note. Table 3 shows the performance of mathematics teacher graduates in specialization courses in LET 2018-2023. The following is the abbreviation and corresponding meaning: *M* mean, *SD* standard deviation, % level of performance, 81 – 86 good, 87 – 91 very good, 92 – 96 superior.

Overall, it means that even though the appraisal of the college course grades is higher than their actual LET ratings, the trend reflects an alignment between what the students can do inside the classroom and their performance in the LET. It implies that if they perform low in



the courses that comprise significant weight in the LET, they will also perform low. It also means that the TOS released by the PRC is a helpful guide for review planning for mathematics teacher graduates and teacher education institutions.

The findings of the study are similar to that of Abao et al. (2023), with a total of 2,780 respondents who took the exam nationwide from the year 2017-2019; they also found that the teacher education graduates performed better in general education ($M=84.91\%$) than the professional education and specialization which have a lower LET performance of only 80.93% and 80.28%, respectively. The present study's findings also confirm the study of Alova (2021), who found the same trend with the lowest performance in professional education and concluded that the overall mean score in the LET was passing but generally relatively low, especially in professional education. Recommendations include a LET review highlighting the professional education courses.

Professional Education and Specialization Courses that have a significant relationship with LET ratings

The related literature and studies share common findings that the LET takers perform highly in general education but not in specialization or professional education. Hence, this study focuses on specific professional and specialization courses significantly related to their corresponding LET ratings in professional education and specialization.

Table 4 summarizes the professional education courses with low to moderate correlations to the LET performance in professional education. Findings show that the mathematics teacher graduates performance in the child and adolescent learners and learning principle, facilitating learner-centered teaching, technology in teaching and learning, teaching internship, and assessment in learning courses were negligibly correlated or not significantly related with their LET performance in professional education. Only three professional education courses were found to be significantly correlated with the LET performance. The mathematics teaching graduates performance in the teacher and school curriculum is significantly correlated with their LET performance in professional education with $r = .678$ and $p < .001$, interpreted as a moderate positive correlation. The teaching profession and the foundation of inclusive and special education (principles of teaching and learning) were also found to be significantly correlated with their LET ratings in professional education with $r = .483$ and $r = .331$, respectively, both with $p < .01$ and interpreted as low positive correlation.

Table 4. Professional education courses that have significant relationships with LET ratings in professional education

Professional Education Courses	Pearson Correlation Coefficient (r)				Rank
	<i>r</i>	<i>Int.</i>	<i>p-value</i>	<i>Int.</i>	
The Teacher and School Curriculum	.678	M	<.001	S	1
Teaching Profession	.483	L	.003	S	2
Foundation of Inclusive and Special Education (Principles of Teaching and Learning)	.331	L	<.001	S	3

Note. The following is the abbreviation and corresponding meaning: *Dependent Variable*: Professional Education LET Ratings; *p-value* ≤ 0.01 : *S* Significant (2-tailed); (.30 to < .50) *L* low positive correlation, (0.50 to < .70) *M* moderate positive correlation.

It means a positive relationship exists between these three college course performances and the LET ratings of the mathematics teacher graduates in professional education. It means that as their performance increases in these courses, their LET performance will also increase. It

implies that the teacher and school curriculum and the teaching profession courses are the first two important courses in the field of education.

In specialization courses as shown in table 5, nine courses were found to significantly correlate with the mathematics teaching graduates LET performance in specialization courses. The college and advanced algebra, abstract algebra, and integral calculus courses were found to be significantly correlated with $r = .616$, $r = .587$, and $r = .579$, respectively, all with a p -value of $<.001$, interpreted as a moderate positive correlation. The analytic geometry, number theory, plane and solid geometry, differential calculus, history of mathematics, and seminar in technology in mathematics were all found to have a significantly low positive correlation with LET performance in the specialization. It can be observed that based on the TOS of the PRC, the history of mathematics comprised around 7% of the total questions, while the other courses that were found to be significantly correlated comprised 63% of the total test questions. Adding them all, it will be 70% of the total test questions in the specialization.

It means that as mathematics teacher graduates' performances increase in these courses, especially in college and advanced algebra, abstract algebra, and integral calculus, their LET ratings in the specialization will also increase. It implies that students should give more weight or time to studying these courses and its pre-requisites while in college to align with the skills being measured in the LET. It also implies that since college and advanced algebra was being offered in the very beginning of the first year students, it will serve as their foundation in learning mathematics.

Table 5. Specialization courses that have significant relationships with LET ratings in specialization

Specialization Courses	Pearson Correlation Coefficient (r)				Rank
	<i>r</i>	<i>Int.</i>	<i>p-value</i>	<i>Int.</i>	
College and Advanced Algebra	.616	M	<.001	S	1
Abstract Algebra	.587	M	<.001	S	2
Integral Calculus	.579	M	<.001	S	3
Analytic Geometry	.463	L	<.001	S	4
Number Theory	.445	L	<.001	S	5
Plane and Solid Geometry	.412	L	<.001	S	6
Differential Calculus	.391	L	<.001	S	7
History of mathematics	.390	L	<.001	S	8
Seminar in technology in mathematics	.370	L	.001	S	9

Note. The following is the abbreviation and corresponding meaning: *Dependent Variable:* Specialization LET Ratings; *p-value* ≤ 0.01 : *S* Significant (2-tailed); (.30 to $< .50$) *L* low positive correlation, (0.50 to $< .70$) *M* moderate positive correlation.

Hence, instructional planning, intervention as needed, and enhancement activities will be helpful. Matthews & Farmer (2008) suggested the use of differentiated instruction to address different levels of learning and ability, increased class discussions on mathematics concepts rather than the traditional lecture-based instruction, and avoid too much homework instead engage students in higher learning level activities to increase performance in mathematics particularly beginning in algebra.



Regression Models as Significant Predictors of LET Ratings in the Specific Domains of Professional and Specialization Courses

This study made use of regression analysis to develop a formula for making predictions about the mathematics teacher graduates' LET ratings specifically in professional education and specialization. According to Borghans et al., (2016) grades are generally better predictors of life outcomes because it does not only capture intelligence but also personality traits to that course. In this study, the college courses grades (independent variables) are regarded as the causes of the LET ratings (dependent variable). It also determined the estimate of the magnitude of its effect to the dependent variables, if any. The required sample was determined through power analysis and all assumptions for the use of regression analysis were satisfied.

Regression model for professional education

As shown in Table 6, the study arrived at two models that demonstrate a high value of R^2 and are significant ($p < 0.05$). The first model is the combination of the three courses: the teacher and school curriculum, the teaching profession, and the foundation of inclusive education, which predicted mathematics teacher graduates' LET performance in professional education, $R^2 = .620$, $F(3, 73) = 39.717$, $p < .001$, interpreted as highly significant. The second model is the combination of the two courses: the teacher and school curriculum, and the teaching profession which predicted mathematics teacher graduates' LET performance in professional education, $R^2 = .604$, $F(2, 74) = 56.381$, $p < .001$, interpreted as highly significant.

Table 6. Model Summary: Predictors of LET Performance in Professional Education

Model	Predictors	R	R^2	Adjusted R^2	Standard Error	F	Sig.
1	(Constant) The Teacher and School Curriculum, The Teaching Profession, Foundation of Inclusive and Special Education	.787	.620	.604	2.232	39.717	<.001
2	(Constant) The Teacher and School Curriculum The Teaching Profession	.777	.604	.593	2.264	56.381	<.001

Note. Dependent Variable: Professional Education LET Ratings

The value of R^2 shows the percentage of the LET performance that can be explained by the college courses. The first model can predict 62% of the changes in the mathematics teacher graduates' LET performance in professional education, while model 2 can predict 60.4%. The effect size (Cohen's f^2) indicates that both models have a large effect on the mathematics teacher graduates' LET performance in professional education, with $f^2 = 1.63$ and $f^2 = 1.53$, respectively.

In selecting what regression model to recommend as the best predictor, the value of adjusted- R^2 is considered. It can be observed that the model 2 has the goodness of fit considering the very minimal increase in R^2 of model 1 when the foundation of inclusive and special education course is being added. It means that the course added to the independent variables is not significant in model 1 and may cause overfitting. In addition, after checking the difference between the values of R^2 of both models and variance inflation factor (VIF), the

study found that it is more convenient to recommend model 2 with 60.4% explanatory power and only two college courses as predictors– the teacher and school curriculum and the teaching profession.

Table 7 shows the coefficients of the recommended regression model. No linear collinearity was found between the independent variables since both VIFs equal 1.026.

Table 7. Coefficients: Predictors of LET Performance in Professional Education

Variable	β	SE	95% CI		Beta	p-value	VIF
			LL	UL			
(Constant)	98.908	1.939	95.045	102.771		<.001	
The Teacher and the School Curriculum	-3.762	.452	-4.662	-2.861	-.617	<.001	1.026
The Teaching Profession	-5.347	1.033	-7.405	-3.289	-.384	<.001	1.026

Note. Dependent Variable: Professional Education LET Ratings

The Beta values mean the teacher and the school curriculum can account for 62%, and the teaching profession accounts for 38% in every increase in LET rating for one standard deviation. Hence, the recommended regression model equation for predicting mathematics teacher graduates' LET performance in professional education is given by Eq. (1) where y is the predicted LET rating in professional education, x_1 is the grade in the teacher and the school curriculum, and x_2 is the grade in the teaching profession course. The grades should follow the college grading system of the National where 1.00 is the highest grade and 5.00 is the failing grade.

$$y = 98.908 - 3.762x_1 - 5.347x_2 \quad (1)$$

The findings of the study show that among the professional education courses, the performance of the mathematics teacher graduates in the teacher and school curriculum and the teaching profession courses have a large effect and it can be used to determine their future performances in the LET in professional education. It implies that knowledge and skills of the mathematics teacher graduates in these two courses should be enhanced before graduation to ensure success in the LET. Looking to the description of these courses, it is notable that other important topics from other professional education courses are also being integrated into these courses during the discussions as on how to relate them to the curriculum and the profession (CHED Memorandum no. 72, 2017). The results confirm the findings of Abao et al. (2023) that there is an alignment between the college courses curriculum and what is being measured in the LET. It also confirms the findings of Navida and Cocal (2022) that low passing rate of teacher education graduates is attributed to their low performance in the professional education, in this study, particularly in the teacher and the school curriculum and the teaching profession courses.

Regression model for LET specialization

Table 8 shows the recommended regression model with the largest effect size for predicting mathematics teacher graduates' LET performance in the specialization. After regression analysis, combining the three courses: college and advanced algebra, abstract algebra, and integral calculus, predicted mathematics teacher graduates' LET performance specialization, $R^2 = .571$, $F(3, 73) = 32.407$, $p < .001$, interpreted as highly significant. The



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value of R^2 shows the percentage of the LET performance that can be explained by the specialization courses. The regression model can be accounted for 57.1% of the changes in the mathematics teacher graduates' LET performance in the specialization. Moreover, the effect size (Cohen's f^2) indicates that the regression model has a large effect on the mathematics teacher graduates' LET performance in specialization, with $f^2 = 1.33$.

Table 9 shows the coefficients of the recommended regression model. No linear collinearity was found between the independent variables, as manifested by VIF. The Beta values indicate that college and advanced algebra has the highest percentage of accountability to every one-unit standard deviation increase in the LET performance in specialization at 36.6%, followed by abstract algebra at 30.3% and integral calculus at 29%.

Table 8. Linear Regression Analysis of the Predictors of LET Performance in Specialization

Predictors	R	R^2	Adjusted R^2	Standard Error	F	Sig.
(Constant)	.756	.571	.554	2.234	32.407	<.001
College and Advanced Algebra, Abstract Algebra, Integral Calculus						

Note. Dependent Variable: Specialization LET Ratings

Hence, the recommended regression model equation for predicting mathematics teacher graduates' LET performance in specialization is given by Eq. (2) where y is the predicted LET rating in specialization, x_1 is the grade in college and advanced algebra, and x_2 is the grade in abstract algebra, and x_3 is the grade in integral calculus course. The grades should follow the college grading system of the National where 1.00 is the highest grade and 5.00 is the failing grade.

$$y = 103.062 - 2.797x_1 - 2.555x_2 - 1.939x_3 \quad (2)$$

The study's findings show that the most critical course among the courses included in the study is the college and advanced algebra course. In addition, abstract algebra enhances students' ability to construct mathematical proofs and develop symbolic thinking and appreciation of mathematics structures, and the integral calculus course further develops students' understanding of differential and integral calculus (CHED Memorandum no. 75, 2017).

Table 9. Multiple Regression Model: Predictors of LET Performance in Specialization

Variable	Beta	SE	95% CI		β	p	VIF
			LL	UL			
(Constant)	103.062	1.784	99.506	106.618		<.001	
College and Advanced Algebra	-2.797	.673	-4.139	-1.455	-.366	<.001	1.325
Abstract Algebra	-2.555	.755	-4.059	-1.050	-.303	.001	1.363
Integral Calculus	-1.939	.599	-3.133	-.745	-.290	.002	1.363

Note. Dependent Variable: Specialization LET Ratings

It means that the performance of mathematics teacher graduates in these three courses significantly predicts their performance in the LET specialization. It implies that the collective efforts of mathematics teacher graduates and teacher education institutions can be represented by their performances in these courses. It also implies that skills developed from

the college and advanced algebra, abstract algebra, integral calculus, and its pre-requisite courses have a large share of the 63% allotted to process and problem-solving in LET specialization. This confirms the statement of Star et al. (2015) that knowledge of algebra is the key to success in future mathematics courses, including geometry and calculus, and all required proficiency in the course plays crucial roles in advanced mathematics courses. Knowledge and skills in algebra are also necessary for post-secondary success in developing a skilled workforce and technical careers.

Conclusions and Recommendations

Based on the findings, this study concludes that the LET in general education is mainly focused on measuring the intellectual skills of the LET takers, mainly in mathematics, science, English for specific purposes, history, and the life of National Hero course; the teacher and school curriculum, teaching profession, and other practical skills in teaching internship were given more weight in LET in professional education. The LET in specialization emphasises procedural fluency and problem-solving skills in mathematics content courses, particularly college and advanced algebra, abstract algebra, calculus, and its prerequisites; mathematics teaching and learning processes; and its history. The mathematics teacher graduates' college course grades from 2018-2023 are aligned with their LET performance, specifically in professional education and specialization. The mathematics teacher graduates' combined performance in the courses, the teacher and the school curriculum, and the teaching profession has a large effect and significantly predicts their LET performance in professional education. The combined performances in college and advanced algebra, abstract algebra, and integral calculus courses have a large effect and significantly predict LET performance in the specialization.

The following are the recommendations of this study:

- (1) Ensure alignment between instructional practices and LET competencies, incorporating diverse methods such as instructional materials, practical activities, and assessments.
- (2) Curriculum emphasis and content focus on intellectual skills in science, mathematics, history, and the life of National Hero; prioritise practical skills in the teacher and school curriculum, the teaching profession, and teaching internship; and highlight procedural fluency and problem-solving skills in college and advanced algebra, abstract algebra, and calculus and its pre-requisites.
- (3) Develop outcomes-based learning activities tailored to each course's learning outcomes in the syllabus, targeting specific LET competencies specified in the PRC specifications table.
- (4) Introduce LET-type comprehensive examinations in general, professional, and specialization courses after 3rd year in the college, enhancing retention and mentoring policies.
- (5) Improve enhancement classes by incorporating recommended regression models for professional and specialization courses to predict mathematics teaching graduates LET performance.
- (6) Stratify students based on regression model results to tailor intervention and enhancements for more effective outcomes.
- (7) Implement targeted professional development, specially for teachers handling courses that are significant predictors of LET performance in professional and specialization,



focusing on refining instructional practices and aligning them with the competencies emphasised in the LET.

Limitations

The context of this study was the National. A similar study can be conducted in other countries. Additionally, increasing the sample size to include representatives from various regions in the National would enhance the study's reliability and help validate the identified predictors.

Declarations

Acknowledgments: *The study acknowledges the participants and the Office of the Vice-President for Academic Affairs and the College of Education for their consent to access the data.*

Funding: *Bicol State College of Applied Sciences and Technology*

Ethics Statements: *The study adhered to all ethical standards and protocols.*

Conflict of Interest: *The authors declare no conflict of interest.*

Informed Consent: *Informed consent was obtained from all participants prior to their inclusion in the study.*

Data availability: *The data supporting the findings of this study are available from the corresponding author upon reasonable request.*

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RESEARCH ARTICLE 07

Inquiry-Based Lessons in Pre-Calculus for Senior High School Students

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Asia Pacific Journal of Educational Perspectives, 8(1), 19–31

Original publication: 2021

Inquiry-Based Lessons in Pre-Calculus for Senior High School Students

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Date Received: November 26, 2020; Date Revised: January 20, 2021

**Asia Pacific Journal of
Educational Perspectives**
Vol. 8 No.1, 19-31
May 2021
ISSN: 2782-9332 (Print)

Abstract – *This study investigated the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Employing pre-experimental research design, it made use of quantitative research method in answering the problems in the study. Nine lessons were taught to forty-seven Grade 11 Science, Technology, Engineering and Mathematics (STEM). The learners' mastery of learning competencies and HOTS were assessed through parallel-form 30-item and 10-item pretest and posttest, respectively while the learners' attitude towards Mathematics was assessed using the attitudes towards mathematics inventory. Quantitative data were treated using mean, mastery level, t-test, and Cohen's index (d). T-test revealed significant differences on the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and HOTS before and after the intervention. Consequently, through inquiry-based lessons with the use of the instructional materials develops learners' mastery of learning competencies in Pre-Calculus, attitude towards Mathematics and HOTS. Hence, there is a need for teachers to design classroom tasks geared towards the development of these skills. Further validation of the said instructional materials packaged out of the lessons as a result of the study is hereby recommended.*

Keywords – *inquiry-based lessons, learning competencies, attitudes towards mathematics, higher-order thinking skills, instructional materials*

INTRODUCTION

Mathematics is valued across civilizations for its power to model and solve complicated problems and for its own simple beauty. In human societies, mathematics plays a critical and unique role and represents a strategic key to the progress of all humanity [1]. In looking at mathematics education, Mathematics is known as one of the major learning challenges to learners [2]. The common belief among learners is that learning mathematics is difficult [3]. This difficulty can be observed in the results of international, national and division Mathematics tests.

In the 2018 Programme for International Student Assessment (PISA), a student assessment of 15-year old learners across 79 countries done by the Organization for Economic Co-operation and Development (OECD), the Philippines ranked in the low 70s with 353 points against a 489 OECD average for Mathematics category [4]. In the 2008 Trends in International Mathematics and Science Study (TIMSS), even with only the science high schools participated in the advanced Mathematics category, the Philippines ranked lowest [5]. Further, according to the 2017 World Economic Forum Executive Opinion

Survey, the Philippines ranked 76th out of 137 participating countries in the quality of math and science education [6].

In the Bicol Region, the low performance in Mathematics of students was shown on the 2017 National Achievement Test (NAT) results wherein the Mean Percentage Score (MPS) obtained in Mathematics is 35.52. In one of the divisions in the Bicol region, the NAT MPS in Mathematics for school year 2016 – 2017 was 34.74%, very far from 75% performance level. In one of the national high schools for instance, the NAT MPS in Mathematics for the same school year is 34.04% which is 40.96% away from the mastery level of 75%.

The problems on students' poor performance and skills deficiency in Mathematics have arisen due to some hindrances that affect their ability to progress in the subject. Students might be unable to recall basic facts, rules and formulas in Mathematics and they are not fully aware of some of the different mathematical terms and concepts. Aside from these, difficulty in memorizing formulas, analyzing and solving mathematical equations and problems, and knowing the application and real-life connection of the learned

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concepts in their lives were also listed as obstacles in learning the subject [2].

The phenomenon that often happens during the mathematics teaching-learning process is that most students are more passive, reluctant, and afraid or shy to express their opinion; this situation will certainly disrupt the smooth learning and creativity of students in learning activities. Additionally, the teaching-learning process is still centered on the teacher, the teacher tends to communicate in one direction with many providing material and slightly provide opportunities for learners to interact through performance or verbal communication [7]. If this teaching-learning process will still be considered, more students will experience learning difficulties. As such, the expected students' learning outcome may not happen.

Teaching approach is one of the factors affecting students' learning outcomes. Under the teaching approach is the teaching method which helps to determine the success or failure of student learning and teaching activity [8]. The more precise method that is used by teachers in teaching is expected to be more effective in the students' achievement of learning goal [9]. Students' learning achievement is influenced by the two main aspects: the student and the aspects that come from outside the student or environmental aspects, of which 70% are influenced by the ability of the students themselves, and 30% are affected by environment [7]. For this reason, a student-centered teaching approach is needed.

Inquiry-based learning is one of the teaching approaches which is student-centered. The use of inquiry-based approach is anchored on section 5 of RA 10533 which focuses on curriculum development and stresses that "the curriculum shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative, and integrative" [10]. It is an approach in which the classroom environment is characterized by the student being the active participant while the teacher role is decentralized [11]. It is also defined in mathematics as a form of active learning in which learners are given a carefully scaffolded sequence of mathematical tasks and are asked to solve and make sense of them, working individually or in groups [12]. It is often used as an approach to restructure aspects of teacher education and maximize the potential of learners [13].

In an inquiry-based classroom, teachers ought to provide certain kinds of teaching-learning experiences in which students are able to work as young

mathematicians or researchers. In short, students should develop their mathematical knowledge, skills and attitude through inquiry-based teaching. The inquiry teaching methodology is built on the Principles and Standards for School Mathematics [14] and the report of Project 2061's benchmarks for science literacy (American Association for the Advancement of Science [15]. They both claim that inquiry is a high-quality teaching to involve students in mathematics learning and development processes and also say that students have enough opportunities to use the inquiry cycle while learning mathematics to perform their own mathematical research. [16]. While inquiry learning is a valued educational reform strategy, in today's classrooms, it is not being successfully implemented [17] – [19].

According to Sanjaya [20], inquiry learning is a set of learning exercises that objectively and analytically emphasize the process of reasoning in order to discover and find their own solution to the problem in question. It is founded on the premise that there is an inherent desire for people to discover their own expertise. The primary aim of research learning is to help students improve academic discipline and thinking skills by offering curiosity-based questions and answers [20].

With the inquiry learning method, it will train students to dare to express views and discover their own knowledge that is useful for problem solving [7]. The efficient and successful use of inquiry learning methods would minimize the monopoly of teachers in mastering the direction of the learning process, and reduce the students' boredom in a class [21].

Based on the phenomenon mentioned that often occurs during the teaching-learning process, improving student learning outcomes and experiences are utmost concern. Thus, a study on improving student learning outcomes through inquiry-based learning is necessary considering the persistent low achievement of students in Mathematics as revealed by the cited measures such as PISA, TIMSS and National Achievement Test, students' less engagement in the subject based on the mentioned literatures and previous researches, the researcher conceptualized this study to determine the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitude towards Mathematics and higher order thinking skills while they are subjected to the inquiry-based approach and to develop an instructional materials that can be packaged out of the lessons as a result of the study. Hence, it is hoped that this study would improve students'

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performance in Mathematics through the developed instructional materials using inquiry-based lessons.

OBJECTIVES OF THE STUDY

This study generally aimed to develop inquiry-based lessons in Pre-Calculus for Senior High School. Specifically, it examined the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Further, it tried to develop instructional materials packaged out of the lessons as a result of the study.

MATERIALS AND METHODS**Research Design**

Quantitative research method employing descriptive and pre-experimental research design were used to answer the research problems. The type of pre-experimental research design used in this study is the one group pre-test/post-test. The design was utilized in the analysis of the learners' mastery of learning competencies, attitude towards mathematics, and higher order thinking skills test in Pre-Calculus using Teacher-Made Test (TMT), Attitudes toward Mathematics Inventory (ATMI), and Teacher-Made HOTS Test (TMHOTST), respectively.

Respondents

The respondents of the study were the Grade 11 learners of one of the national high schools in the Philippines during the 1st semester of school year 2019 – 2020 selected using the purposive sampling technique as the sampling design. The class was composed of 47 learners, 22 male and 25 female, enrolled in Science, Technology, Engineering and Mathematics (STEM) strand under the Academic Track. The respondents were chosen because they already have sufficient knowledge and strategies in learning mathematics.

Research Instruments

The lessons developed from the implementation using inquiry-based approach were constructed based on the curriculum guide given by the Department of Education. The inquiry-based lessons include problem-based, project-based and design-based activities and integration of philosophical views as the key features. The lessons utilized guided and structured inquiry using 5 E's (Engage, Explore, Explain, Elaborate and Evaluate) instructional model.

The developed nine inquiry-based lessons were subjected to critiquing by six experts in the field: two Master Teachers in Mathematics, two Philippine Science High School Mathematics Teachers, a Mathematics Professor in State Universities and Colleges (SUC's) and a Curriculum Expert and at the same time Director for Senior High School. They were asked to give their comments, suggestions, and recommendations on each part of the lesson for the improvement of the lesson plans. The lessons were finalized based on the corrections and suggestions given by the panel of experts.

Learners' attitudes toward mathematics were determined through the standardized Attitude Towards Mathematics Inventory (ATMI) by Tapia and Marsh [2]. The ATMI is a 40-item Likert scale inventory composed of statements on attitudes toward mathematics. The 40-item inventory represents four dimensions: value of mathematics (10 items), motivation to learn mathematics (5 items), enjoyment of mathematics (10 items), and self-confidence (15 items) as reflected in the item specifications of the instrument. The overall validity of ATMI was confirmed for 0.615, and the reliability or Cronbach α is 0.932 [23].

Learners' mastery of learning competencies and higher order thinking skills in Pre-Calculus were assessed through a teacher-made 30-item multiple choice and 10-item problem solving and mathematical reasoning pre-tests and post-tests, respectively. After identifying the learning competencies included in the lessons, the researcher prepared two sets of 30-item and 10-item parallel tests considering the learning competencies in the lessons making sure that the test items were representatives of those which were included in the lessons. The tests were constructed following the table of specifications. The pre-test and post-test contained the same types of questions, multiple choice, problem solving and reasoning. Only few items in multiple choice test and problem solving and mathematical reasoning were included since some questions required students' solutions to the problems and the test was only allotted for one hour and 45 minutes. The tests were evaluated and critiqued by the mathematics educators consisting of two Master Teachers, two Philippine Science High School Teachers, a Professor in SUC's, and a Curriculum Expert and at the same time Director in one of the private universities.

The mathematics pre-test and post-test were revised before the conduct of pilot testing to one of the nearby

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schools offering STEM strand. Item analyses and reliability testing were made to determine the difficulty and discrimination indices and reliability of each item which helped the researcher decide on the final draft of the tests. After the item analysis and reliability testing, the final drafts of the mathematics pre-test and post tests were composed of 30-item multiple choice (MC) and 10 – item higher order thinking skills (HOTS) tests. The rubric adapted from Northwest Regional Educational Laboratory [24] was used for HOTS test scoring.

Data Gathering Procedure

A letter requesting to conduct the study was prepared and given to the Schools Division Superintendent of the Department of Education and to the School Head of the setting of the study on July 15, 2019 for approval. Upon approval on the same date, the researcher prepared the lessons and pre-test-post-tests using the Curriculum Guide for Pre-Calculus and submitted to experts for validation and critiquing. The lessons, pre-test and post-test were validated and critiqued on the 22nd – 26th day of July 2019. After which, revisions were done based on the suggestions of the panel of experts. The pre-test and post-test were pilot tested to the Grade 11 STEM students in one of the nearby schools of the locale of this study on 5th day of August 2019 for item analysis and reliability test purposes. After item analysis and reliability testing, the final drafts of the pre-test and post-test were done.

On the second week of August 2019, the Attitude Towards Mathematics Inventory (ATMI) and Mathematics Pre-Tests were administered to the respondents on two consecutive days. The ATMI was lasted for 15-20 minutes while the mathematics pre-test was lasted for 45 minutes to one-hour of completion. The learners were not asked to check the test for the validity of scoring.

A week before the intervention, the learners were grouped into 8 for the entire IBL sessions wherein the 7 groups consisted of 6 members and 1 group consisted of 5 members. Groupings were based on the learners' academic standing (rank) using their first quarter grade in the subject as basis. Each learner is assigned with a number from 1-47 corresponding to their respective rank. The first 8 in the rank is assigned as leader or in-charge of the group. Learners with corresponding ranks from 1-8, 9-16, 24-17, 25-32, 33-40 and 41-47 occupied the first, second, third, fourth fifth and sixth row, respectively. Numbering for rows 1, 3, and 5 started form left to right while numbering for rows 2, 4,

and 6 started from right to left. The numbers from each column correspond to the groupings wherein the first, second, third, fourth, fifth, sixth, seventh and eight columns are groups 1, 2, 3, 4, 5, 6, 7, and 8 respectively.

After the administration of the inventory and tests, the intervention was started on 27th day of August 2019 and ended on the 11th day of October 2019. On the 14th day of the same month, the mathematics post-test was administered to the respondents and the ATMI was also administered on the following day. After completing the inquiry-based learning episodes, post-tests and ATMI were conducted on the 16th to 17th of October, 2019 during the availability of the learners.

Data Analysis

Cohen's index (d) was employed to measure the effect size (r) of the inquiry-based learning on learners' performance, attitudes toward mathematics, and higher order thinking skills in terms of ATMI inventory before and after the intervention and mathematics pre and post-tests, respectively. The effect size was interpreted based on Cohen's standard. A d-value higher than 0.8 indicates large effect, between 0.2 and 0.8 indicates medium effect, and a d-value between 0 and 0.2 indicates small effect.

The t-test (test of difference) was employed to measure whether the observed differences in the pre-tests and post-tests mean scores in the ATMI and mathematics tests (learning competencies and HOTS) will be significant. In testing the significant differences between means, both the t-value together with its corresponding p-value was used: p-values less than 0.05 were significant while those greater than 0.05 was interpreted as Not Significant (NS). Effect sizes were computed and reported in the results. In computing for the t-value with its corresponding p-value, Minitab 17 software was utilized.

Ethical Considerations

Respondents were informed that they were selected purposively as participants and informed consent from their parents through letter was secured by the researcher. The confidentiality of respondents' test scores, and outputs was assured.

RESULTS AND DISCUSSION**Lessons Developed in Pre-Calculus using Inquiry-Based Approach**

The emphasis of the lessons developed is on teaching using inquiry-based approach that is anchored

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on section 5 of RA 10533. The approach was considered since it focuses on curriculum development and it is based on one of the underlying learning principles and theories of the K to 12 mathematics curriculum framework intended to develop the mathematics knowledge, skills and attitude among K to 12 learners.

The lessons which were developed consisted of topics in Trigonometry focusing on circular functions. Weber [25] stated that Trigonometry is an important course in the high school curriculum. Understanding trigonometric functions is a pre-requisite for understanding topics in Newtonian physics, architecture, surveying, and many branches of engineering. Further, trigonometry is one of the earliest mathematics topics that links algebraic, geometric, and graphical reasoning, it can serve as an important precursor towards understanding Pre-calculus and Calculus.

Circular functions as one of the topics in Trigonometry is very important since it has many applications in various fields such as architectures, surveyors, astronauts, physicists, engineers and even crime scene investigators. It is indeed necessary that the learners will be able to learn circular functions, see its importance or applications and its large part in their daily lives. Thus, this study focused on the topics in Trigonometry which are deemed necessary in learning mathematics subject in the higher levels of education.

The lessons utilized 5 E's instructional model, a teaching-learning approach that is founded on the belief that learners learn by building new ideas on top of old ones. Using this model, learners can understand and learn concepts and skills over a series of five steps or phases of learning. This learning model is beneficial in classrooms as it can motivate learners, engage learners in an active teaching-learning process, facilitate collaboration and teamwork and help learners form conclusions through questioning, investigating, observing, analyzing, reasoning and problem-solving.

Based on the learning competencies of the Curriculum Guide for Grade 11 STEM subject, there were nine (9) lesson plans that were developed by the researcher for the content circular functions. Lessons 1-3 deal with the angles in a unit circle that include angle measure, angles in standard position and coterminal angles, and arc length and area of a sector. Lessons 4-5 focus on basic concepts of circular functions that include circular functions on real numbers and reference angle. Lessons 6-8 deal with the graphs of

sine, cosine, cosecant, secant, tangent and cotangent functions. Lesson 9 deals with situational problems on circular functions.

The inquiry-based lesson has five (5) parts namely, the objectives, content, learning resources, procedures and assignment. In the objective part, the content standard, performance standard and the learning competencies are included. The content part includes the lesson and specific topics. In the learning resources, the references used that includes the teacher's guide, learner's material and textbooks are included. Geogebra Learning Materials (Applet) was used as other learning resources. The procedures contain the most important part of the inquiry-based lessons wherein the significant key features of the developed lesson can be found. In the procedures, the use of problem-based, project-based and design-based activities and integration of philosophical views as the key features were highlighted. The 5 E's instructional model was used to carry out the procedures particularly the inquiry-based lesson. This model focuses on the five (5) main events in the teaching-learning process. These are engage, explore, explain, elaborate and evaluate. The 5E teaching model [26] can be used to develop a science lesson and is based on the cognitive psychology, principle of constructivist learning, and science teaching best practices. Bybee [26] declares that "using this approach, the students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment".

Effectiveness of the Developed Inquiry-Based Lessons

The mastery of learning competencies, attitudes towards Mathematics and higher order-thinking skills in inquiry-based lessons included were measured by 30-item validated teacher-made parallel pre-test and post-test, attitudes towards math inventory (ATMI) by Tapia and Marsh [22] and 10-item teacher-made parallel HOTS pre-test and post-test, respectively.

Mastery of Learning Competencies in Pre-Calculus

The mastery of learning competencies of the learners in the inquiry-based lessons included was measured by a 30-item multiple choice teacher-made parallel pre-test and post-test. Table 1 shows the results of the pre-test and post-test given to the learners categorized according to the lessons and the mastery level attained reported in percentage.

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Table 1. *Pre-Calculus Pre-Test & Post-Test, Mean Scores, Performance Level, t-Test and Cohen's Index*

Learning Competencies	No. of Items	Pre-Test		Post-Test		t-value	p-value	Interpretation	Cohen's Index (d)	Effect Size (r)
		Mean (ML)	Interpretation	Mean (ML)	Interpretation					
1. Illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle	4	2.32 (58%)	Low Mastery	3.21 (80%)	Average Mastery	-4.19	0.000	Significant Effect	0.86	0.40 (medium)
2. Convert degree measure to radian measure, & vice versa	2	0.74 (37%)	Low Mastery	1.77 (88%)	Moving Towards Mastery	-8.27	0.000	Significant Effect	1.66	0.64 (large)
3. Illustrate angles in standard position and coterminal angles	2	0.98 (49%)	Low Mastery	1.98 (99%)	Mastered	-10.40	0.000	Significant Effect	2.03	0.71 (large)
4. Illustrate the different circular functions	4	1.74 (44%)	Low Mastery	3.17 (79%)	Average Mastery	-7.21	0.000	Significant Effect	1.30	0.54 (large)
5. Use reference angles to find exact values of circular functions	3	0.87 (29%)	Very Low Mastery	3.28 (82%)	Average Mastery	-11.92	0.000	Significant Effect	1.96	0.70 (large)
6. Determine the domain and range of the different circular functions	2	0.60 (30%)	Very Low Mastery	1.60 (80%)	Average Mastery	-6.71	0.000	Significant Effect	1.43	0.58 (large)
7. Graph the six circular functions (a) amplitude, (b) period, and (c) phase shift	10	3.40 (34%)	Very Low Mastery	8.06 (81%)	Average Mastery	-17.32	0.000	Significant Effect	2.70	0.80 (large)
8. Solve situational problems involving circular functions	3	0.66 (22%)	Very Low Mastery	2.06 (69%)	Average Mastery	-9.70	0.000	Significant Effect	1.88	0.68 (large)
Total	30	11.32 (38%)	Low Mastery	24.21 (81%)	Average Mastery	-22.49	0.000	Significant Effect	3.09	0.84 (large)

Note: At 5% or 0.05 level of significance

Data in Table 1 shows that the mean scores of the learners on the lessons during the pre-test were interpreted as low mastery for learning competencies 1-4 while learning competencies 5-8 were interpreted as very low mastery.

Looking at the data as shown in Table 1, the highest mastery level during the pre-test was on the learning competency “illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle” (58%) while the lowest performance level was on the learning competency “solve situational problems involving circular functions” (22%). During the post-test, the learners obtained the highest mastery level on the learning competency “illustrate angles in standard position and

coterminal angles” (99%) while the lowest performance level was on the learning competency “solve situational problems involving circular functions” (69%)

Data also revealed that learners mastered the learning competency “illustrate angles in standard position and coterminal angles”, moving towards mastery on the learning competency “convert degree measure to radian measure”, & vice versa while average mastery for the learning competencies “illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle”, “illustrate the different circular functions”, “use reference angles to find exact values of circular functions”, “determine the domain and range of the different circular functions”,

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“graph the six circular functions (a) amplitude, (b) period, and (c) phase shift”, and, “solve situational problems involving circular functions.” Overall, the total mean score of the pre-test which was 11.32 and post-test of 24.21 classified as low mastery and average mastery, respectively showed a marked difference between the mastery of learning competencies of the learners from pre-test to post-test.

Based on the table, the differences noted on the mean scores during the pre-test and post-test on eight (8) learning competencies were all significant including the learning competency “solve situational problems involving circular function” which displayed very low mastery level as shown by the t-values and p-values. Moreover, the effect sizes for all learning competencies were all large based on the Cohen’s index (d) and coefficient of effect size (r) except for the learning competency 1 with medium as the effect size. Of the eight learning competencies included in the study, the highest effect size was found on learning competency 7, “graph the six circular functions (a) amplitude, (b) period, and (c) phase shift” (0.80) followed by the learning competency 3 “illustrate angles in standard position and coterminal angles” (0.71) while the least on learning competency 1 “illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle” with only 0.40.

Overall, the results of the pre-test and post-test was

significant with $t = -22.49$ and $p = 0.000$ tested at 95% confidence level. To determine the overall effect size, Cohen’s index (d) was used resulting to $d = 3.09$ and $r = 0.84$ interpreted as large effect. With mean scores of 11.32 and 24.21 for pre-test and post-test respectively, showing an increase of 12.89, it can be deduced that the implementation of inquiry-based lessons produced positive impact on the learners’ mastery of learning competencies in terms of the lessons included in the study. Hence, the developed inquiry-based lessons are effective in enhancing the learners’ mastery of learning competencies in Pre-Calculus. This is similar to the finding of Bernido & Boyon [27] that the use of inquiry based learning is effective in understanding lessons in Pre-calculus. The result of this study is also similar to the result of Kuklok [28] that after the learners learned and implemented inquiry-based practices, their self-advocacy and academic achievement increased showing that these practices affected learners in a positive manner.

Attitudes towards Mathematics

The attitudes of the learners towards Mathematics along value, motivation to learn, enjoyment, and self-confidence were determined using the weighted mean score. Table 2 illustrates the pre-test and post-test mean scores of the learners on statements along the four dimensions.

Table 2. Pre-test and Post-test Mean Scores of the Learners on Statements along Value, Motivation to Learn, Enjoyment and Self-Confidence in Mathematics

Statements	Pre-Test	Post-Test
Value of Mathematics		
Mathematics is a very worthwhile and necessary subject.	4.64	4.55
I want to develop my mathematical skills.	4.77	4.74
Mathematics helps develop the mind and teaches a person to think.	4.45	4.68
Mathematics is important in everyday life.	4.49	4.60
Mathematics is one of the most important subjects for people to study.	4.34	4.55
High school math courses would be very helpful no matter what I decide to study.	4.04	4.02
I can think of many ways that I use math outside of school.	3.70	3.64
I think studying advanced mathematics is useful.	4.32	4.47
I believe studying math helps me with problem solving in other areas.	4.13	4.13
A strong math background could help me in my professional life.	4.19	4.21
Motivation to Learn Mathematics		
I am confident that I could learn advanced mathematics.	3.57	3.62
I would like to avoid using mathematics in college.	3.19	3.26
I am willing to take more than the required amount of mathematics.	3.53	3.83
I plan to take as much mathematics as I can during my education.	3.68	3.23
The challenge of math appeals to me.	3.57	3.83

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Table 2 (cont.) Pre-test and Post-test Mean Scores of the Learners on Statements along Value, Motivation to Learn, Enjoyment and Self-Confidence in Mathematics

Statements	Pre-Test	Post-Test
Enjoyment in Mathematics		
I get a great deal of satisfaction out of solving a mathematics problem.	3.81	4.23
I have usually enjoyed studying mathematics in school.	3.57	3.96
I like to solve new problems in mathematics.	3.45	3.81
I would prefer to do an assignment in math than to write an essay.	3.19	3.17
I really like mathematics.	3.34	3.81
I am happier in a math class than in any other class.	3.00	3.23
Mathematics is a very interesting subject.	3.94	4.04
I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	3.09	3.49
I am comfortable answering questions in math class.	3.26	3.19
Self-confidence in Mathematics		
Mathematics is one of my most dreaded subjects.	3.34	3.45
My mind goes blank and I am unable to think clearly when working with mathematics.	3.45	3.53
Studying mathematics makes me feel nervous.	3.40	3.79
Mathematics makes me feel uncomfortable.	3.15	3.49
I am always under a terrible strain in a math class.	3.28	3.64
When I hear the word mathematics, I have a feeling of dislike.	2.51	3.23
It makes me nervous to even think about having to do a mathematics problem.	3.26	3.43
Mathematics does not scare me at all.	2.91	3.15
I have a lot of self-confidence when it comes to mathematics.	3.00	3.49
I am able to solve mathematics problems without too much difficulty.	2.96	3.30
I expect to do fairly well in any math class I take.	3.32	3.64
I am always confused in my mathematics class.	3.36	3.81
I feel a sense of insecurity when attempting mathematics.	3.36	3.74
I learn mathematics easily.	2.89	3.38
I believe I am good at solving math problems.	3.17	3.53

In value of mathematics dimension as shown in Table 2, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "mathematics helps develop the mind and teaches a person to think" (0.23). However, declines on the mean scores of some statements were also noted, the statement, "mathematics is a very worthwhile and necessary subject" showed the highest decrease of 0.09. The overall mean score along value of mathematics was 4.31 to 4.36 (0.05) which were both interpreted as slightly positive. This implies that learners fairly valued Mathematics as a subject considering their attitudes towards math scores along the statements included in the dimension.

In motivation to learn mathematics dimension, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "I am willing to take more than the required amount of mathematics" (0.30). However, declines on the mean scores of some

statements were also noted, the statement, "I plan to take as much mathematics as I can during my education" showed the highest decrease of 0.45. The overall mean score along motivation to learn mathematics was 3.51 to 3.55 (0.04) which were both interpreted as slightly positive. This implies that learners' motivation to learn Mathematics denote a slight change based on the revealed mean scores on attitude towards learning the subject.

In enjoyment of mathematics dimensions, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "I really like mathematics" (0.47). However, declines on the mean scores of some statements were also noted, the statement, "I am comfortable answering questions in math class" showed the highest decrease of 0.07. The overall mean score along enjoyment of mathematics was 3.29 to 3.52 (0.23) which were interpreted as neutral and slightly positive, respectively. This implies

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that learners' manifested higher increase on enjoyment of Mathematics as revealed by the mean scores on attitude towards learning the subject.

Lastly, in the self-confidence in Mathematics dimension, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "When I hear the word mathematics, I have a feeling of dislike" (0.72). However, declines on the mean scores of some statements were also noted, the statement, "My mind goes blank and I am unable to think clearly when working with mathematics" showed the highest decrease of 0.08. The overall mean score along enjoyment of mathematics was 3.16 to 3.51 (0.35) which were interpreted as neutral and slightly positive, respectively. The result implies that learners exhibited higher increase on self-confidence in Mathematics as revealed by the mean scores on attitude towards learning the subject.

To determine how effective are the developed inquiry-based lessons on the learners' attitude towards mathematics from pre-test to post-test, the mean scores for each dimension were subjected to t-test and Cohen's index shown in Table 3.

The data in Table 3 show that the mean scores of the pre-test and post-test along value of mathematics and motivation to learn mathematics were not significant while enjoyment and self-confidence in mathematics were significant. This implies that in terms of value of mathematics and motivation to learn mathematics dimensions, no significant impact was noted. The

absence of significant impact of the inquiry-based lessons in terms of the value of mathematics is possibly due to the learners' fair level of viewpoint and appreciation of the usefulness, relevance and worth of the subject now and in the future. In terms of motivation to learn mathematics, the absence of significant impact is possibly due to learners' average level of understanding and skills acquired in the inquiry-based lessons. Further, learners' beliefs at an average level on the interest in mathematics and the desire to pursue studies plausibly contributed to the absence of significant impact of the lessons.

Analysis of the effect size using Cohen's index shows small effect on value of mathematics, motivation to learn mathematics and enjoyment of mathematics with a d-value of 0.15, 0.16, and 0.44, respectively. On the other hand, large effect was noted on self-confidence in mathematics with d-value of 1.51. The overall mean score of the learners' attitude towards mathematics from pre-test to post-test were 3.52 to 3.74, respectively and were both classified as slightly positive. The mean score had a difference of 0.22, while the t-value of $t = -5.96$ and p-value of 0.000 were significant at 95% confidence level. Hence, it could be concluded that the implementation of inquiry-based lessons has significant influence on the learners' attitude towards mathematics in terms of the lessons included in the study. This substantiates the result of the study conducted by McGregor [29] that inquiry-based learning has positively influencing and reshaping learners' beliefs and attitudes towards Mathematics.

Table 3. Pre-Test and Post-Test Mean Scores, t-Test, and Cohen's Index on Attitude towards Mathematics

Scales	Pre-Test		Post-Test		t-value	p-value	Interpretation	Cohen's Index (d)	Effect Size (r)
	Mean	Interpretation	Mean	Interpretation					
Value of Mathematics	4.31	Slightly Positive	4.36	Slightly Positive	-1.47	0.176	Not Significant	0.15	0.07 (Small)
Motivation to Learn Mathematics	3.51	Slightly Positive	3.55	Slightly Positive	-0.32	0.764	Not Significant	0.16	0.08 (Small)
Enjoyment of Mathematics	3.29	Neutral	3.52	Slightly Positive	-3.60	0.006	Significant	0.44	0.21 (Small)
Self-Confidence	3.16	Neutral	3.51	Slightly Positive	-8.35	0.000	Significant	1.51	0.60 (Large)
Overall	3.52	Slightly Positive	3.74	Slightly Positive	-5.96	0.000	Significant	0.39	0.19 (Small)

Note: At 5% or 0.05 level of significance

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Table 4. Pre-Test and Post-Test Mean Scores, t-Test, and Cohen's Index on Higher Order Thinking Skills in IBL in Pre-Calculus

Component	Pre-Test		Post-Test		t-value	p-value	Interpretation	Cohen's Index (d)	Effect Size (r)
	Mean	Interpretation	Mean	Interpretation					
Conceptual Understanding	1.13	Emerging	2.54	Proficient	-23.63	0.000	Significant	4.16	0.90 (Large)
Strategies & Reasoning	1.11	Emerging	2.53	Proficient	-23.62	0.000	Significant	4.32	0.91 (Large)
Computation & Execution	1.12	Emerging	2.51	Proficient	-21.82	0.000	Significant	4.00	0.89 (Large)
Communication	1.13	Emerging	2.48	Developing	-23.61	0.000	Significant	4.30	0.91 (Large)
Insights	1.12	Emerging	2.47	Developing	-23.55	0.000	Significant	4.40	0.91 (Large)
Overall	1.12	Emerging	2.51	Proficient	-24.58	0.000	Significant	4.57	0.92 (Large)

Note: At 5% or 0.05 level of significance

Learners' higher order thinking skills in inquiry-based lessons were measured by a validated 10-item Problem Solving and Mathematical Reasoning teacher-made parallel pre-test and post-test. The problem-solving and mathematical reasoning type of test focused on the lesson about circular functions and situational problems involving circular functions. The test requires learners to use their higher order thinking skills along analyzing, evaluating and creating level which are the last three aspects of the Bloom's taxonomy [30]. Hence, HOTS is the highest part of Bloom's taxonomy of cognitive process dimension.

Table 4 shows the results of the pre-test and post-test given to the learners categorized according to the HOTS components and mean.

The higher order thinking skills component included in this study were based on the rubric adapted from Northwest Regional Educational Laboratory. This includes conceptual understanding, strategies and reasoning, computation and execution, communication and insights [24]. Conceptual understanding deals with learners' interpretation of the problem using mathematical representations and procedures that accurately reflects the importance of mathematics in the problem. Strategies and reasoning consider evidence that the learners proceeded from a plan, applied appropriate strategies, and followed a logical and verifiable process toward a solution. Computation and execution focus on the solution performed in an accurate and complete manner given the approach taken by the learners. Communication is considered if the learner was able to easily understand his/her thinking or if the learner is tasked to make inferences and guesses about what they were trying to do. While

insights deals with the learners' ability to better grasp the deeper structure of the problem and see how the process used in solving the problem connects it to other problems or real-world" applications.

The scales used in the adapted rubric are emerging, developing, proficient and exemplary with 1, 2, 3 and 4 rating scale, respectively. The rating details or descriptions per component and scale were presented in the adapted rubrics itself.

Data in Table 4 shows that the mean scores of the learners on the higher order thinking skills in all components during the pre-test were interpreted as emerging. Looking at the data, the highest mean score of 1.13 during the pre-test was noted on conceptual understanding and communication components while the lowest mean score of 1.11 was on strategies and reasoning. During the post-test, learners' mean scores in the conceptual understanding, strategies and reasoning, and computation and execution components were interpreted as proficient while in the communication and insights components were both interpreted as developing. Furthermore, the learners obtained the highest mean score of 2.54 on conceptual understanding while the lowest mean score of 2.47 was noted on insights component.

To determine how effective are the developed inquiry-based lessons on the learners' higher order thinking skills from pre-test to post-test, the mean scores for each component were subjected to t-test and Cohen's index shown in Table 4. The data shows that the mean scores of the pre-test and post-test in all higher order thinking skills components were significant. Analysis of the effect size using Cohen's index shows large effect on conceptual understanding,

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strategies and reasoning, computation and execution, communication, and insights with a d-value of 4.16, 4.32, 4.00, 4.30, and 4.40, respectively.

Overall, the results of the pre-test and post-test was significant with $t = -24.58$ and $p = 0.000$ tested at 95% confidence level. To determine the overall effect size, Cohen's index (d) was used resulting to $d = 4.57$ and $r = 0.92$ interpreted as large effect. With the overall mean scores of 1.12 and 2.51 for pre-test and post-test interpreted as emerging and proficient, respectively and showing an increase of 1.39, it can be deduced that the implementation of inquiry-based lessons produced significant and affirmative effect on the learners' higher order thinking skills in terms of the lessons included in the study. The result is consistent with the study conducted by Mensah-Wonkyi & Adu [31] that students who underwent inquiry-based instruction approach of teaching performed better in post-test in terms of their conceptual understanding as one of the HOTS components included in this study. Similarly, the result is also consistent with another study conducted by Zulfiani, et. al. [32] that a significant increase of higher order thinking skills towards student ability categories is manifested from both guided inquiry and free inquiry learning model.

Instructional Materials Packaged out of the Lessons as a Result of the Study

The instructional materials packaged out of the lessons as a result of the study include lessons, learning activities and assessment tools saved in the Compact Disc (CD) and uploaded to www.slideshare.net website for Pre-Calculus teachers' consumption. The instructional materials as the output of this study may serve as one of the supplementary teaching-learning resources by the Pre-Calculus teachers in the Senior High School level. These resources maybe utilized by them in teaching Trigonometry content dealing with circular functions. The slide presentations, learning guide cards and geogebra learning applets which are included under the lessons maybe used by the teachers to facilitate the teaching-learning process while the learning activities (problem-based, project-based and design-based) and assessment tool (evaluation worksheet) maybe used to facilitate the teaching-learning activities of the inquiry-based lessons. These activities may contribute in enhancing their learners' learning competencies, creativity, problem solving and higher order thinking skills in the subject.

In terms of the usefulness or relevance of this output to the new normal in education, the instructional

materials may be used by the Pre-Calculus teachers as one of the additional or supplementary teaching-learning resources in their online teaching. Using the www.slideshare.net website, teachers may search and download the said resources that may aid them in preparing their respective online teaching materials for their learners. These resources may also be included in the preparation of self-directed modules as part of the Learning Continuity Plan (LCP) of the Department of Education in the new normal by considering the content and/or found in the said resources such as the learning activities and assessment tools.

CONCLUSION AND RECOMMENDATION

The developed inquiry-based lessons in Grade 11 Pre-Calculus utilizing inquiry-based approach included topics in Trigonometry which consisted of angle measure, angles in standard position and coterminal angles, arc length and area of a sector, circular functions on real numbers, reference angle, graphs of sine and cosine functions, graphs of cosecant and secant functions, graphs of tangent and cotangent functions and situational problems involving graphs of circular functions with problem-based, project-based, design-based activities and integration of philosophical views as key features. The said lessons are effective in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Lastly, the instructional materials packaged out of the lessons as a result of the study include lessons which consist of slide presentations, learning guide cards and Geogebra learning applets; learning activities which consist of the problem-based, project-based and design-based activities; and assessment tool that include the evaluation worksheets.

As inquiry-based lessons effected positively, teachers need to carefully design inquiry-based lessons suited to the teaching-learning approach in teaching Mathematics considering the use of problem-based, project-based & design-based activities and integration of philosophical views as key features of the developed lessons. They also need to consider the learners' knowledge & skills in preparing learning activities focusing on project-based and design-based activities. Further, they need to embrace the said approach & other teaching-learning approaches geared towards the enhancement of the basic knowledge & skills but more so on problem-solving & higher order thinking skills.

Considering the developed lessons in teaching Pre-Calculus using inquiry-based approach had significant

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effect in enhancing the learners' mastery of learning competencies, attitudes towards Mathematics and higher order thinking skills, teachers should venture to use the said approach in their classroom.

Based on the results of this study, there is hope that through inquiry-based lessons with the use of the instructional materials packaged out of the lessons will develop learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. A replication of this study on inquiry-based lessons in Pre-Calculus to large sample of respondents in the local setting might further provide additional information to support the present claim.

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RESEARCH ARTICLE 08

Solid Waste Management in Naga City: Its Culture of Information Dissemination

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Asia Pacific Journal of Multidisciplinary Research, 7(4), 12–17

Original publication: 2019

Solid Waste Management in Naga City: Its Culture of Information Dissemination

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Date Received: June 13, 2019; Date Revised: August 5, 2019

Asia Pacific Journal of
Multidisciplinary Research
Vol. 7 No.4, 12-17
November 2019
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com
CHED Recognized Journal
ASEAN Citation Index

Abstract – People suffer from serious pollution problems caused by the generation of large quantity of waste. Studies conducted that Solid Waste Management (SWM) showed minimal impacts to the community in some areas in the Philippines like Naga City. This paper evaluated the effectiveness on the implementation of SWM system in Naga City in terms of information dissemination. This also analyzed the awareness of the household heads on the programs and its level of priority by the Local Government Units (LGUs). The study adopted descriptive-evaluative design of mixed methods of research. Structured questionnaires, interviews and FGDs were used for data gathering to the selected respondents such as household heads, LGU's and SWM Office key persons of nine (9) Barangays and selected schools in Naga City, Philippines. Based on the findings of the study, households were "slightly aware" of different SW management programs, the City has "not given much priority" in informing the public on the different SWM programs; also, its implementation in terms of information and dissemination were "slightly effective." The results of these findings will help LGU, NGOs and other stakeholders in enhancing policies on SWM problems specifically, issues in terms of information dissemination. This will give rise to a better, more effective, sustainable and culturally acceptable SWM developmental plan that will alleviate City's problem on waste.

Keywords – waste, effectiveness, programs, management, dissemination

INTRODUCTION

Industrialization always challenges the natural environment. By the year 2050, the world is expected to increase waste generation by 70 percent, from 2.01 billion tons of waste in 2016 to 3.40 billion tons of waste annually [1]. Solid Waste Management (SWM) has become one of the most pressing problems globally. But, there are no universal solutions applicable to every geographical and social context [2]. We, too, have to consider people's acceptability due to various beliefs and also the economic status of our country. Given the fact that, most high-income countries can afford to spend more to incorporate Reuse, Recycle and Reduce (3R) technologies, focusing on "Zero Waste" and/or "Zero Landfilling" which is certainly expensive for countries with weaker economies [3]. Industrialization always challenges the natural environment. By the year 2050, the world is expected to increase waste generation by 70 percent, from 2.01 billion tons of waste in 2016 to 3.40 billion tons of waste annually. The Republic Act 9003 of January 26, 2001 promotes national research and development programs for improved solid waste management and resource conservation techniques, more effective institutional arrangement and indigenous and improved methods of waste reduction, collection, separation and recovery. However, waste management

campaigns must begin with the dissemination of information [4] to secure the public's health and necessary for proper management planning [5]. The involvement of all the stakeholders such as the waste generators, waste processors, government and non-governmental organizations and financing institutions is a key factor for the sustainable waste management [6].

Literatures have proven that sound SWM systems in every community can be associated with several factors: support system from the grassroots, resources of the government and the culture of information and dissemination. The absence of those factors is largely responsible for poor implementation of SWM in any community.

In the Philippines, the mentality towards cleanliness, the sense of responsibility towards properly managing waste, as well as public concerns like not separating waste for recycling are critically lacking [7]. Indeed, its sustainability for public awareness [8] must be addressed. Some local authorities tend to allocate their limited financial resources to SWM programs and projects because local government has limited financial capacity; other locally important projects such as infrastructure and the like were their main focus. A study conducted locally that most of the households rely on

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local government's garbage collection and few of them religiously follow the recycling, composting and reusing practices. Despite city ordinance, still some of the households burn their waste and dump/throw in riverways [9]. This proves that despite the presence of RA 9003 about creating the necessary institutional mechanisms and appropriating funds for SWM programs, some SWM initiatives showed minimal impacts in some cities and provinces in the Philippines.

In Naga City, the Bicol River is seen to be polluted, largely resulted from SWM improper waste disposal of household specifically where houses are located near the river banks. Apart from that, poor drainage system in some areas during rainfall can make the low lying-communities of Naga City become flooded. Necessary intervention should be implemented to solve the problems for SWM before they will be "buried by their own waste". There is a 10-year comprehensive development plan initiated by the government aimed to revitalize the river until year 2020. The local government of Naga City has designed an 84-kilometer drainage system. This had addressed some problems on flooding. This adverse effect due to improper implementation of waste disposal is perceived as a perennial problem even by the National Government. The Barangay LGUs are expected to play major role in its implementation, but there was a major lapse in the awareness level of households which led to poor waste management practices. These observations helped us realized the importance of information dissemination as a strategy for sustainable waste management.

Nevertheless, this study hopes to provide guidance to LGUs and other stakeholders, in the implementation of SWM system not only in Naga City but also those with similar problems along recycling, collection and disposal. And consequently, the local government should examine safe, effective, sustainable and culturally acceptable waste management practices in some parts of the world. This will also enable the LGUs to enhance their SWM plans if there is a need to recreate the institutional mechanisms as well as imposed penalties for any violation of any of its provisions

OBJECTIVES OF THE STUDY

This paper evaluated the effectiveness of the implementation of SWM system in Naga City in terms of information dissemination. It analyzed the awareness of the household heads on the programs and its level of priority by LGUs. This also considered the effectiveness of SWM programs in terms of information dissemination. A proposed SW intervention should also

be considered. Results will provide guidance in identifying safe, effective, sustainable and culturally acceptable waste management practices.

METHODS

Quantitative method of research and Descriptive-evaluative were employed in an attempt to assess the culture of information dissemination on SWM Programs in selected barangays in Naga City for the year 2018. Specifically, it determined the level of awareness of the household heads of the programs on the proper waste management; assessed the level of priority of the barangay officials in the implementation of the waste management programs; and evaluate the effectiveness of its implementation in terms of information dissemination. The research instrument data were gathered using a three-part structured questionnaire prepared in Mother Tongue language and subjected to pilot testing to ensure feasibility and content validity. The computed Cronbach's Alpha was 0.794 and was deemed acceptable according to a standard scale [10].

The first part aimed to collect the profiles of the household-respondents. The second part comprised several statements to assess the level of awareness on SWM Programs, using the 5-point likert scale metrics. Respondents were asked to choose series of response like "fully aware", "moderately aware", "slightly aware" and "not aware". For the second portion, the questions were focused on LGU's Level of Priority, options were follows: "Not a priority", "Low priority", "Somewhat priority", "Moderate Priority", and "High priority". The third part of the questionnaire was focused on the Effectiveness of SWM programs in terms of information and dissemination, options were-"highly effective", "moderately effective", "somewhat effective", "slightly effective", "not effective".

The cluster sampling technique was utilized to facilitate the selection process. The respondents included in this study were 189 household heads of nine (9) selected barangays of Naga City. These were categorized as highly urbanized with 75 respondents from Dinaga, Penafrancia and San Francisco; moderately urbanized (30) like Concepcion, San Felipe and Bagumbayan and 46 respondents for Cararayan, Pacol and Carolina as low urbanized barangays in Naga City. To support the analysis and to compare information, interviews and Focus Group Discussions (FGDs) with key stakeholders like SWM Office (SWMO) officer and task force were also used to generate different ideas from them. These were conducted concurrently to validate quantitative results used as bases for generalization of research

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outcomes; hence, mixed method of data collection was obtained. Review of related documents was also considered. Data gathered were statistically interpreted using frequency count and weighted mean.

RESULTS AND DISCUSSION

From the global perspective, the issue of waste management is becoming increasingly important. Given the increasing amount and diversifying content of waste, countries should seek out sustainable waste management options, which protect both local and global environment [11]. In Naga City, when Bicol River overflows, the incidence of flooding occurs throughout the City most especially the central business districts. These areas are extremely affected and at the same time the residents' lives are put at risk. Specific approaches are therefore required for designing adequate waste management systems [12]

According to SWM office, only five (5) of the 27 barangays in Naga City have such functional Materials Recovery Facility (MRF). This received mixed waste material for final sorting of the residual wastes and transferred to a sanitary landfill. Seven (7) barangays have MRF with mechanical problems and 10 barangays lack space for establishing adequate MRF. Although, the City Government intends to install MRF Equipment to some of the barangays soon; this is in compliance with the provisions of Republic Act 9003 or the Ecological SWM Act. Likewise, some residents complained from foul odor emanating from the city's garbage dumpsite. These hazardous and contaminated air from the garbage dumpsite create an obvious threat to human health.

The development of SWM information dissemination in Naga City is just about establishing a routine data collection on waste. There were approved policies on management of waste, but strict implementation should be pursued to make them effective [13]. This will support the

issue on decision-making of the City's authorities on waste management.

Awareness on SWM Programs

SWM is a challenge for the cities' authorities in some developing countries mainly due to the uncontrolled generation of waste [14]. Nowadays, little participation was manifested coming from sectors such as the LGUs, other GOs, private and households. Their awareness on SWM Programs significantly contributes to its effectiveness. Also, Enhancing residents' SWM awareness was considered as the most effective method for it success. In this study (see Table1), SWM activities in the City such as prohibits burning garbage with ($x=3.02$), waste segregation(2.99), MRF (2.36) plastic for rice (2.27), sanitary landfill (2.58), no plastic policy(2.38), pera sa basura (2.68), waste water treatment (2.57), and regular rabuz/declogging (2.93), revealed that the community was willing to take part in SWM programs. However, respondents have "little knowledge" and they were "Slightly Aware" of it.

Gaining public support can facilitate policy implementation [15]. One of problems faced by the City government is on how to disseminate the knowledge of the SW programs at the grassroots level. The waste generators themselves have contributed big part to that particular problem, which is why they should be aware of it. And some SWM Office initiated waste reduction programs were not sustained because of some political issues, attitudes and lack of social acceptability among the residents.

As such, there is a need of public awareness on SWM programs and policies. For more active participation of the community in waste reduction, an urgency for more strategic planning for the local LGUs and SWM taskforce, stakeholders' awareness campaigns at the grass roots level should be regularly implemented taking into account their culture, attitudes and beliefs.

Table 1. Awareness on SWM Programs

Programs	Highly Urbanized Brgy.	Moderately Urbanized Brgy.	Low Urbanized Brgy.	Total Weighted Mean	Interpretation
Prohibits burning garbage	3.1	2.9	3.05	3.02	Moderately Aware
Waste segregation	3.1	2.8	3.06	2.99	Slightly Aware
Materials Recovery Facility (MRF)	2.1	2.4	2.58	2.36	Slightly Aware
Plastic for rice	2.1	2.3	2.4	2.27	Slightly Aware
Sanitary landfill	2.4	2.5	2.83	2.58	Slightly Aware
No plastic policy	2.3	2.4	2.44	2.38	Slightly Aware
Pera sa basura	2.6	2.5	2.93	2.68	Slightly Aware
Waste water treatment	2.6	2.4	2.72	2.57	Slightly Aware
Regular rabuz/declogging	2.8	2.9	3.03	2.93	Slightly Aware
Total				2.64	Slightly Aware

Table 2. Information dissemination's level of priority for SWM

Information Dissemination	Highly Urbanized	Moderately Urbanized	Low Urbanized	Total Weighted Mean	Interpretation
Seminars on SWM policies and programs	2.8	2.7	2.7	2.73	Low priority
Establishment of garbage collection system	2.7	2.9	3.2	2.93	Low priority
Total				2.83	Low priority

LGU's Level of Priority

Decision-making in terms of SWM problems often requires the different stakeholders such as government, municipalities, industries, experts, and/or general public to be involved [16]. Therefore, access to information by the public is useful in changing positive attitudes and beliefs of the community. Table 2 shows that seminars on SWM with (2.73) and establishment of garbage collection system (2.93) or "Low priority". The average mean of 2.83, the City's information dissemination's level of priority of LGUs on SWM in Naga City, "Low priority." On this account, the Local Government Unit (LGU) through SWM Office should disseminate information at the grassroots level. Additionally, cost-saving waste reduction measures awareness campaign should also be strictly implemented to industrial and commercial centers that highlight the current issues and future directions of SWM of the city.

Surveys and interviews reflected that information dissemination for SWM has given "low priority" by the City LGUs. Although there have been efforts made through information campaigns which is done year round. But then, the strategies used by local authorities in the implementation of SWM programs were not sustained.

According to respondents, the major problems that hinder people to participate in the SW activities were the following: (a) lack of interest to attend SWM campaign; (b) inadequate time from the LGUs to monitor the activity; (c) lack of funds to create skilled workforce; (d) unsupported legal and regulatory frameworks and (e) not LGUs priority.

In compliance with Republic Act No. 9003, activities on segregation, recovery of recyclable materials at the barangay level were properly implemented. The City has maintained its cleanliness along the Commercial Area or Central Business District. But then, monitoring, evaluation and follow up activities for waste reduction could be the most important component of it sustainability. Also political responses undermines decision making on proper management of wastes [17]. We can also reduce waste generation if LGU, residents and stakeholders mutually cooperate.

Effectiveness of information dissemination

In most parts of the world the vision is to develop sustainable strategies towards zero waste. Although, it seems like wishful thinking, yet positive change can only be brought about by setting higher goals [18]. LGUs in Naga City have developed strategies by implementing different simple but holistic SWM Programs (see Table 3). On the routine basis, the wastes generated by the different houses and other establishments are collected by the Naga City garbage collectors using garbage trucks and deposited in the City Dumpsite.

Naga City SWM board is always headed by the City Mayor himself. The board implements the SWM plans and programs for the different barangays. A monthly meeting with Kalinigan Warriors Officer (a barangay representative for SWM Board) was conducted to address problems and issues. Information dissemination was done through billboards, letters and other Education and Communication (IEC) materials. There were indeed lectures/trainings/ seminars done regularly. Different sectors from the community and industry were encouraged for the use of composting and recycling. Similarly, SW Deputies and taskforce were created to monitor activities at the same time promote recycling programs. Little has been achieved however, due to the lack of participation and lukewarm attitudes from the public [19]. And some programs implemented were "slightly effective" (see Table 3) due to the people's attitudes and beliefs and political will of the barangay officials. There was no strict implementation to the household members for segregation of waste, their apprehensions that if it will be strictly implemented, the constituents might be upset and this will affect their political career.

There were provisions in SWM but close monitoring was not fully implemented by the barangay taskforce. Similarly, according to interviews, seminars were conducted but only few attended for the reasons that some LGU officials only invited supporters, friends, relatives and neighborhoods.

Table 3. Effectiveness of SWM programs terms of information and dissemination.

Programs	HU	MU	LU	WM	Interpretation
Prohibits burning garbage	3.1	2.8	2.7	2.87	Slightly Effective
Waste segregation	3.0	2.7	3.1	2.93	Slightly Effective
MRF	2.5	2.5	2.7	2.57	Slightly Effective
Plastic for rice	2.2	2.3	2.0	2.17	Slightly Effective
Sanitary landfill	2.2	2.3	2.7	2.40	Slightly Effective
No plastic policy	2.3	2.3	2.3	2.30	Slightly Effective
Pera sa basura	2.3	2.7	3.1	2.70	Slightly Effective
Waste water treatment	2.4	2.4	2.9	2.57	Slightly Effective
Regular rabuz/declogging	2.8	2.9	2.6	2.77	Slightly Effective
Total				2.59	Slightly Effective

The program is also not fully imposed due to “ningas cogon” attitude (enthusiastically starting things, but then quickly losing enthusiasm soon after), and lack of fund. If the volume of generated wastes in the barangays were reduced due its partial implementation of the policy, then there is really a need for its strict implementation until the current volume of wastes generated in the barangay level is further reduced. Setting up of material recovery facilities (MRF) in every barangay is one of the components for the reduction of waste. Some mandatory SWM policies were proved to be effective. But then, several inadequate financial resources, and poor governance often lead to poor solid waste management system.

Solid Waste Intervention Program

A. Program Title: SWM Technology Based Monitoring System

B. Target Community: Naga City

C. Target Beneficiaries: Household members and LGUs

D. Duration: 1 year Pilot Study

E. Objectives: The Solid Waste Intervention Program aims to establish integrated SWM technology based monitoring system for solid waste management activities in Naga City. Specifically, this will be able to:
a. determine the effectiveness integrated technology based system in sustaining SWM; and
b. encourage the community to implement integrated technology based system.

F. Implementation:

Project Components Overview

The overconsumption of non-recyclable resources in Naga City increases the volume of City’s solid waste every day. The proposed system is developed to address environmental concerns associated with the variety of waste disposed. This represents a modern and systematic approach to solid waste management. This project uses

the available ICTs and their application in SWM to facilitate the efficiently manage waste collection strategies. This would contribute to the solid waste collection optimization.

Description

This practically demonstrates how electronic engineering can contribute to improve cities’ management systems... A waste collection providing the area trashcans with embedded sensors. This bin can read and transmit trash volume data over the Internet/Wireless Sensor Network. In comparison to a traditional waste collection approaches this data highlighted initiatives to contribute and develop a solution for SWM.

CONCLUSION AND RECOMMENDATION

The challenge for government authorities whether it is in local or national unit, is to prepare a well-designed solid waste management plan incorporating issues on information dissemination with its stakeholders down to the grassroots level. Aside from the common household practices such as burning of waste, burying some of them and no proper segregation of solid waste; still, households rely on garbage collection managed by the government. They believed that garbage collection and disposal is the responsibility of the government. Given the fact that, the city government promotes Reuse, Recycle and Reduce (3R) technologies, focusing on “Zero Waste” which is certainly part of its efficient information dissemination plan.

In recent days, Naga City Government sees waste as a potential resource. There were initiated and implemented waste reduction programs but unfortunately some of them were not sustained. Households were “slightly aware” on different SWM programs. SW Management authorities have not fully involved the household in the implementation of the SWM activities. It is therefore perceived by the local residents that the city government had “not given much

priority” in the information dissemination of the SWM activities. As a result, information and dissemination was “slightly effective.” Political issues, attitudes and lack of social acceptability among the residents are some reasons for these findings.

A more comprehensive waste management plan with well-designed strategies can be the first phase. Strict implementation of some mandatory policies will enhance its sustainability; its full implementation may require appropriate funding from LGUs. Trainings or seminars can be conducted at the grassroots level on the different SW programs. It is therefore suggested that the local units should allocate funds for training and seminars with active participation of different stakeholders but most importantly the households.

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RESEARCH ARTICLE 09

Growth Mindset in Mathematics among Ninth-Grade Students via 5Ps Learning Model

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Southeast Asian Mathematics Education Journal, 11(2)

Original publication: 2021

Growth Mindset in Mathematics among Ninth-Grade Students via 5Ps Learning Model

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Abstract

This paper determined the effects of implementing the Prepare, Perform, Process, Ponder, and Practice (5Ps) learning model in teaching ninth-grade students' growth mindset in mathematics. This study employed the quasi-experimental design and mixed-method research approach to answer the research questions with 60 ninth-grade students at a public secondary high school in the Philippines. The study administered a growth mindset questionnaire, informal interviews, learning journals, and Focus Group Discussions (FGD) on identifying learning experiences and mindsets of the students. Findings presented that employing the 5Ps learning model significantly influences students' mindset in mathematics. Meanwhile, traditional teaching does not significantly affect students' mindset in mathematics. The implementation of the 5Ps learning model has a significant positive effect on students' growth mindset in mathematics. The results of the study are limited merely to the participants included in the study; similar research utilizing the 5Ps learning model to other learning areas with a larger sample is recommended for more generalizable results.

Keywords: growth mindset in mathematics, 5Ps learning model

Introduction

Mathematics education begins in early education. Wherein progressive schools designed play a crucial role as center of curriculum to teach students about mathematical concepts through firsthand experiences and at the same time possess fun while learning. Its objective is to develop students' cognitive ability to identify shapes, patterns, and connections and help them understand the significance of mathematical applications to the real world.

However, the study of Mazana, Montero, and Casmir (2019) revealed that students exhibit a positive attitude towards mathematics, but their attitude is less positive when the students move to higher levels of education. It displays that as the students' grade level increases, their interest and positive attitude towards mathematics decreases, and it becomes a challenging subject to learn and appreciate as students also develop fixed mindsets.

The PISA 2018 results in the growth mindset. In the Philippines, only 31% of the students possessed a growth mindset, resulting in a score of 353 and ranked 76th, the second lowest ranking among participating countries. The data demonstrates that the students of the countries with higher growth mindsets conducted better than those with a lower growth mindset (OECD, 2018). With a growth mindset, intelligence and "smartness" can be learnt, and that one believes that the brain is able to grow from exercise (Boaler, 2013). Dweck (2016) further asserted that with a growth mindset, students will be able to work hard, perform more effort, and learn effectively, displaying a desire for challenge and resilience of

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the failure. It frequently occurs in mathematics learning. In contrast, students with a fixed mindset believe that they are intelligent or not wise in mathematics.

Park et al. (2016) unveiled that student with a growth mindset possessed higher mathematics achievement levels and that the more the teachers are focused on classroom performance outcomes (learning outcomes), the more students develop fixed mindsets over the school year. They emphasized that concentrating on learning outcomes is similar to saying – “you need to know this by the end of the year”. These words orient students toward performance but away from “learning”. It is in accordance with Blackwell et al. (2007) who explained that fixed mindsets are associated with lower achievement as supported by many conclusive pieces of evidence.

Researchers have revealed that mistakes are significant opportunities for learning and growth (Heinze & Reiss, 2007; Moser, Schroder, Heeter, Moran, & Lee (2011); Sarwadi & Shahrill, 2014), however, students generally regard mistakes as indicators of low ability (fixed mindset). Every time students produce mistakes in mathematics; new synapses are generated in their brains. The students and teachers should value mistakes and should not consider them as learning failures but as learning achievements. If students produce pages of correct work, their brains are not growing, and development opportunities are missed. Conley (2014) employed a growth mindset to provide feedback to students and discovered that students become more persistent and confident in attempting situations and possess happier outlooks.

Madden (2015) revealed that the students with low mindset scores definitely own low homework percentages but many other students with higher mindset scores do too. The study concluded that encouraging a growth mindset in students generates improved learning, motivation to learn, and standardized test scores. Menanix (2015), in his study, discovered that growth mindset instruction coupled with challenging mathematics and opportunities for students to share authority over their learning was significantly more effective at constructively influencing students' mindsets and performance. The study emphasized that when students were deprived of the opportunity to experience a growth mindset by solely working on procedural routine mathematics, they did not possess authority to develop their ideas. Their mindsets did not shift in productive ways for engagement learning.

Furthermore, the study of Amant (2017) uncovered that teacher who scored exhibiting growth mindset characteristics employed activities with higher levels of rigor more frequently, which implies that they plan more rigorous activities or ask more rigorous questions. Boaler (2013) also asserted that teachers' practices that contribute to fixed mindset thinking among students should be addressed. The researcher indicates that further research is required to determine the significance of the idea. Thus, future studies are more able to examine closely the relationship between student's academic achievement and teacher's mindset and practices (Sun, 2015).

With the significance of developing a growth mindset among students and considering the change of students' learning preferences and instruction modes, to the objective of this study is to investigate the effects of utilizing the 5Ps learning model in teaching to the students' growth mindset in mathematics. The 5Ps learning model (5Ps) was developed based on the learning principles and theories provided in the k-12 curriculum guide of the Education Department of the Philippines, comprising the five key steps (*italicized*): *prepare, perform,*

process, ponder, and practice. It was employed as a teaching methodology in designing lesson plans which encompasses three parts: the introduction to the lesson, lesson proper, and closure. The 5Ps learning model was explicitly designed for blended learning and possessed the advantage of emphasizing differentiated instruction particularly along with the key steps *prepare* and *process*. It also administered the key step *ponder* to provide students the avenue to develop a positive attitude and growth mindset in mathematics through reflective learning. Lastly, it also employed differentiated assessment along *practice*, which believes that the students should be provided equal opportunity to be assessed for and of learning.

The study results will be beneficial to the teachers and students in communicating growth mindsets and as a basis for utilizing the 5Ps learning model that suits different learning modalities compared to an existing lesson design because the 5Ps learning model supported the students to develop a growth mindset.

Methods

Research Design

This study administered the quasi-experimental design. The intervention (instructional materials) on the use of 5Ps lesson design and 5Ps-designed activity guide by the teacher and students was employed in the experimental group to determine its effect on students' mindset in mathematics. The controlled group was implemented to compare results without utilizing the intervention; instead, it was taught applying the traditional method following the Activity, Analysis, Abstraction, & Application (4As) lesson design with the assistance of the ninth-grade learners manual. The experimental and controlled groups equally consisted of 30 selected ninth-grade students randomly ($n=60$) from a secondary education institution in the Philippines. The quantitative research method was utilized to examine students' scores in pre-test and post-test mindset questionnaires employing frequency counts to determine the number of students in mindsets scales, paired t-test Cohen's d to identify the difference between the pre-test and post-test scores of students, and effect size of the intervention to the students' mindset in mathematics. The qualitative research method was employed to demonstrate the students' learning experiences by applying informal interviews, journals, and FGD. During the implementation, the students' learning experiences were identified through triangulation in qualitative educational research exhibiting the students' learning journal, interview of the learners, and FGD while they were under the intervention.

Research Procedure

Before the study was conducted, the researcher sought written informed consent from school heads, teachers, parents, and the students. Ethical considerations encompass as informing the parents and participants about the benefits of the study, duration of the students' involvement, the collected data, confidentiality, and that they can withdraw anytime. The researcher demanded a cooperating teacher (mathematics teacher) to implement the intervention and teacher-observers (selected teachers) to assist in observing and recording the learning experiences of the students. A week before implementing the intervention, the cooperating teacher, the actual teacher, decided the classes as a controlled group and

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experimental group through toss coin. After the pre-test on the mindset survey, the intervention was performed, comprised of six lessons in the 4th quarter of the ninth-grade curriculum. The same cooperating mathematics teacher was teaching the experimental group and controlled group.

The experimental group made use of the developed instructional materials. The cooperating teacher followed the 5Ps lesson design in which along *prepare* (5Ps key steps italicized), the students prepared for lessons at home and along *perform*, the students conducted pre-class learning tasks. Along the *process*, there are three stations – a teacher's station, a collaborative station, and a computer station. The cooperating teacher grouped the students based on their learning needs, readiness, and interest, and guided them in rotating to the three stations. At the teacher's station, the students participated in the teacher's discussion, asked questions, verified concepts, received teacher feedback, and performed individualized assessments. At the collaborative stations, the students participated and worked collaboratively with their classmates to accomplish the assigned tasks. At the computer stations, the students reviewed the lecture videos to comprehend the concepts better (with their group) which were previously watched at home and discussed by the teacher. Along *ponder*, the students wrote their learning journals for reflective learning and proceeded to *practice*, in which they accomplished individual lesson assessments. In an instance that there were students who completed the lessons quickly or were performed in the stations, the teacher assigned them to help their classmates with their learning needs to avoid congestion in the stations. During the experiment implementation, some notable aspects were noted. One of the aspects is in terms of the student's interest to study the instructional materials, particularly during the key step *process*. Another aspect is the positive behavior in the intervention application reflected by their eagerness to learn the lessons, motivation to participate in the activities, and persistence to solve practice problems by the students, particularly in the process and practice of the 5Ps learning model key steps. Teacher-observers, teachers invited to observe, were present during the implementations.

In the controlled group, the teacher employed the traditional teaching method following the 4As lesson format and administered the Department of Education ninth-grade learners' manual. The students participated in the activity provided by the teacher at the beginning of each lesson. The teacher presented and discussed the lessons. After the discussions, the teacher equipped students with another activity associated with the topics, then analysis and abstraction, in which the teacher asked questions to solicit higher-order thinking among students. The students summarized the lesson learnt and completed the lesson assessments. After the implementation, the researcher administered a post-test mindset questionnaire, informal interviews, and FGD at each student's home, and the participant applied the minimum health protocol. The unique data gathered in the FGD was the students' statements displaying consensus about their significant learning experiences on the implementation of the 5Ps learning model, which became helpful in the thematic analysis.

Research Tool and Analysis

The effect of the intervention employing the 5Ps learning model on the students' mindset in mathematics was examined by utilizing the interview schedule by Dweck (2006)

questionnaire. In an interview schedule, the researcher inquired each student the question and checked their responses in the mindset questionnaire. The students responded, whether with a growth or fixed mindset, to each statement. A student with a growth mindset with some fixed ideas believed that his/her ability could be enhanced in mathematics, but still, he or she still possessed some fixed ideas that some of his or her mathematical ability could not be changed. On the other hand, a student with a fixed mindset believed that his/her ability in math could not be changed or improved; however, he/she had some ideas that his/her math ability could be changed in some ways. It encompassed 20 statements that reflect growth mindset (items 2, 3, 5, 6, 9, 10, 13, 15, 18 and 19) or fixed mindset (1, 4, 7, 8, 11, 12, 14, 16, 17, and 20). The statements were assigned with the following point values:

Table 1
Point Values of Mindset Questionnaire

Scale	Fixed mindset	Growth Mindset
Strongly Agree	0	3
Agree	1	2
Disagree	2	1
Strongly Disagree	3	0

To verify and obtain students' ideas not caught in the mindset questionnaire, informal interviews, learning journals, and FGD were conducted. Informal interviews were performed because the setting of the interviews was outside the students' homes, and they were instructed to share their learning experiences. After the interviews, the neighboring students were collected for an FGD, which also aims to corroborate their ideas and responses. Learning journals became the source of additional information which also helped in analyzing results.

Results and Discussion

Table 2 presents the summary of the pre-test and post-test frequency counts of the students' mindsets in the experimental and controlled group. There were eight students in the experimental group who possessed a fixed mindset with some growth ideas, while 20 students owned a growth mindset with some fixed ideas, and two students who possessed a strong growth mindset in the pre-test. During the post-test, eighteen (18) students owned a growth mindset, and twelve (12) students developed a strong growth mindset.

Table 2
Summary of the Pretest and Posttest Frequency Counts of Two Groups on Growth Mindset in Mathematics

Mindsets in Mathematics	Pretest		Posttest	
	Experimental Group	Controlled Group	Experimental Group	Controlled Group
Fixed mindset	0	0	0	0
Fixed mindset with some growth ideas	8	3	0	6
Growth mindset with some fixed ideas	20	24	18	21
Robust growth mindset	2	3	12	3
Total	30	30	30	30

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It can be identified that both the students in the experimental and controlled group possessed fixed mindset with some growth ideas in the pre-test, in the post-test, the students of the experimental group developed a growth mindset which increased the numbers of students with robust growth mindset from two to 12 leaving no students with fixed mindsets. However, in the post-test of the controlled group, three students were included in the students with fixed mindsets with some growth ideas, resulting in the increase of students with fixed mindsets.

More specifically, 10 students who were placed into group of students with strong growth mindset during post-test in the experimental group, 9 of them were from Growth Mindset with some fixed ideas, and one of whom originated from fixed mindset with some growth ideas to possessing a strong growth mindset. In contrast, the three students in the controlled who were involved in to possess a fixed mindset with growth ideas in the post-test had a growth mindset with some fixed ideas in the pre-test.

The results revealed that students in the experimental group demonstrated a comprehension of growth mindset role in their learning. Considering the student's statement coming from having a fixed mindset with some growth ideas to a robust growth mindset, she stated in an informal interview:

“Dakula po ang naitabang sakuya kang instructional materials na gamit ang 5Ps learning model ta dahil guided na po ako sa gigibuhon ko sa harong sa pagadal ko, mas nakakaprepay ako sa mga lesson saka sa tabang kang mga kaklase ko narealize ko na maiimprove man talaga ang kakayanan ko sa math kapag nagaadal ako tapos naghihigos sa pagparticipate sa mga activities (The instructional materials that feature the implementation of 5Ps learning model helped me a lot because I am guided on what I am going to apply at home in studying. I can prepare better for the lessons and with the help of my classmates, I realized that my math ability could really be improved if I am studying and being hardworking in participating the activities)”.

Based on the student's statements as previously discussed in their learning experiences, the student's growth mindset development could possibly be attributed to the implementation of the instructional materials, which promotes growth mindset through self-learning that emphasizes efforts in learning mathematics.

In the controlled group, the increase of students having fixed mindset could be attributed to the pressure which the students may experience at a provided time and might be having lesser motivation for self-learning because the teacher reluctantly performed with the classroom discussion only, which also resulted to less one-on-one feedbacking.

To determine if the implementation of the instructional materials along the experimental group impacts students' pre-test and post-test on mindset in mathematics, the mindset scores for each component were subjected to t-test and Cohen's index (Table 3).

Table 3
Pre-test and Post-test mindset scores t-test and Cohen's Index on Mindset in Mathematics of the Two Groups

Groups	t-value	p-value	Interpretation	Cohen's Index (d)	Interpretation
Experimental	5.058	0.000	Significant	0.92	large
Controlled	-1.264	0.216	Not Significant	-	-

The mindset scores of the pre-test and post-test of the experimental group were highly significant, with a t-value of 5.058 and p-value of 0.000 examined at a 95% confidence level. Analysis of the effect employing Cohen's index presented a large effect with $d=0.92$. On the other hand, the pre-test and post-test of the controlled group were not significant, with a t-value of -1.264 and a p-value of 0.216. It is indicated that the computed effect size of this skill is negative. A negative size implies that the effect decreases the mindset scores. To determine if there is a significant difference in the mindset scores of the students between the experimental and controlled groups, a t-test for independent sample was administered. The results revealed a significant difference between mindset scores of the two groups displayed by the t-value of 4.395 and p-value of 0.000, which was significant at a 95% confidence level.

The findings from the study presented that the implementation of intervention significantly affects students' mindset in mathematics, while traditional teaching does not significantly affect students' mindset in mathematics. It implies that the conduct of intervention enhanced students' mindset in mathematics in the experimental group. On the other hand, other factors may affect students' mindset during the implementation of the study due to the delayed post-test of the mindset survey caused by health restrictions. However, based on the data gathered by the study, it was strongly possible that the growth mindset development and robust growth mindset among students in the experimental group could be attributed to the application of the instructional materials.

In the 5Ps key step, *perform*, the students were trained not to be afraid to attempt things and produce wrong answers which results the students are reluctant to perform harder in learning. Along the *process*, the station rotation model encouraged students to learn autonomously and that their knowledge will grow through study and engaged in the activities through stations. At the same time, along *ponder*, the students were expected to reflect on their learning growth and opportunities. Finally, along with the *practice*, the students' patience, perseverance, diligence, eagerness, and other traits were reinforced because they require to strive harder to learn and pass the lesson examination and eventually developed a growth mindset with the assistance of the teacher's encouragement and growth mindset messages. With growth mindsets, students are expected to be more motivated to learn, work harder, are less discouraged by difficulty, and employ more effective strategies for learning.

The result in the controlled group was associated with the finding of Menanix (2015) which revealed that when students were deprived of the opportunity to experience a growth mindset by only working on procedural routine mathematics in which they did not possess

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authority to present with their ideas, their mindsets did not shift in ways that were productive for engagement or learning.

In the study of Boaler (2013), she asserted that teachers and schools are better to constantly communicate messages to students about their ability and learning through instructional and classroom practices (i.e., instructional materials). She then argued that if one possesses a true commitment to the communication and teaching of a growth mindset, a thorough examination of all aspects of teaching is necessary. She emphasized that mindset messages were communicated through questions asked, task, grading and feedback, mistakes, grouping, and norm-setting.

To identify students' learning experiences and mindsets, informal interviews, learning journals, and focus group discussions were conducted. After thematic analysis, the following themes emerged:

Students' Attitude and Mindset about Mathematics Affected Their Learning

Since the 5Ps learning model corroborated mind setting, the students understand the value of attempting and failing to succeed. For this reason, the students comfortably participated during the activities and discussion without being afraid to fail. Furthermore, the students become more motivated to try and learn. In an informal interview, one of the students who developed a robust growth mindset at the end of the quarter shared as follows:

"In my own belief, the students who get smarter understand the topic with more efforts to get the higher achievement. Meaning to say, if you exert an effort to perform things to enhance your knowledge, your life will change, but if you do not do something, you will never find relief in life (Student 18)".

In an informal interview, a student (student 20) shared his experience in trying his best to study at home and at school:

"Dati po sir dae ako nakaka-adal sa harong pero kang naintindihan ko ang importance kang pag-adal lalo na sa math, nagaadal na ako sir. Nagngagalas na ngani sakuya si mama ta nag-aadal na ako ngunian. Nagcocompute ako sir sa harong, uni ang notebook ko sir oh, si mga pigkorompute ko (Before I could not study at home, but when I understood the importance of studying, particularly in math, I am now studying. My mom is wondering because I am now studying. I do computations at home, sir, here is my notebook, the ones that I have been computed)".

The students' statements corroborated the argument of Dweck (2006) that better learning occurs when students comprehend the advantage of trying, failure, and success during the learning process.

Based on the students' statements, the learning process by implementing the 5Ps learning model had upheld students understand the significance of efforts, trying, experiencing failure and success, and untiring "practice" to master the mathematical concepts and possess a full grasp of the learning competences. These lead the students to own a positive attitude on

learning mathematics and a growth mindset affecting their learning performances. This learning principle confirmed one of the learning principles on Mathematics Framework for Philippine Basic Education, which similarly explained “Students’ attitudes and beliefs about mathematics affect their learning” (Science Education Institute - Department of Science and Technology [SEI-DOST] & Philippine Council of Mathematics Teacher Education, Inc. [MATHTED], 2011).

Mathematics Teaching Requires Positive Attitude and Growth Mindset to Perform More Teaching-Learning Efforts.

Boaler (2013) explained that mindset involves “knowing that math is a subject of growth and [the math user’s] role is to learn and think about new ideas.” She also stated that “Many teach mathematics with their fear of the subject.”

A teacher’s mindset manipulates many aspects of his/her teaching and students’ learning, encompassing the learning tasks he provides, how classroom discourse is orchestrated, his response to mistakes, and the assessment practices he employs. When teachers learn about the research behind mathematical mindsets and identify their own current mindsets, they are able to reset their approach to learning and teaching math. They will believe that all students are able to understand and enjoy it and set them all up for success (Chapman & Mitchell, 2018).

With the assistance of instructional materials, the teacher was able to communicate a positive attitude and growth mindset, which was tremendously advantageous in providing an equal learning opportunity for all because the teacher believed that everybody could learn mathematics and that the students just require to possess the right attitude and mindset.

It also substantiated the teaching principle of SEI-DOST and MATHTED (2011) in Mathematics Framework for Philippine Basic Education that “Mathematics can never be learnt in an instant, but rather requires lots of work and the right attitude.” It indicates that teaching mathematics by communicating a positive attitude and growth mindset in mathematics encourages students to conduct more effort into learning. The students are also able to understand the significance of trying, failure, and success during the learning process that eventually will lead to successful enhanced mathematics learning.

Overcoming Challenges in Studying

There are challenges that the students experienced during the implementation of the lessons and activities. One of the challenges was on studying and learning autonomously. From an informal interview, student 10 commented on how the instructional materials helped her, and she stated,

“Kaya ko nang maintindihan ang lesson kahit hindi ito itinuturo dahil nagse- self-study ako na dati na di ko magawa-gawa (I can now understand the lesson even if not taught because I do self-study that I could never perform before)”.

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Student 11 also argued, *“I develop myself being always in the mood to whatever task it has, to easily understand.”*

The statement of student 10 obviously proves that the student’s study habit has been changed for a good while student 11 adjusts her mood (attitude in learning mathematics) so that she is able to understand and learn the lessons. Student 30 also experienced difficulties in performing self-study. However, she also managed to continue studying at home. She reflected, *“I experienced how hard to study by myself because there’s no one to teach me, so I needed to study it and see that my answer was correct when my teacher checked the prepare.”*

The students’ journal entries also present evidence that they have overcome challenges in studying while answering the question, which is does the use of the instructional materials helped you learn? The students answered:

Student 4: “Yes because noong gumamit ako ng activity guide, nadagdagan yung kaalaman ko at lalo ko pang tinibayan para marami pa akong maencountered (Yes because when I used the activity guide, my knowledge increased and so I conducted more effort so that I might learn more)”

Student 9: “Yes, because it helps students in learning. It has self-assessment to comprehend the student’s knowledge employing their own understanding in the lesson. It helps to study hard.”

Student 20: “Yes, dahil mas madali itong matutunan at dahil nagkukusa kami para matutunan and isang bagay na walang nag-gaguide (Yes, because it was easy to learn, and we initiated so we can learn things even nobody is guiding)”

Student 22: Yes, dahil nalalaman ko kung ano-ano ang pagsunod sunod para malaman mo ang tamang sagot at natulungan ako nito para mapalago ang aking kaisipan. Nagustuhan ko ang paggamit ng activity guide dahil mas madali na pag-aaralan kahit nasa bahay lang ako (Yes, because I learnt the steps and corrected answer, hence, it helped me to improve my mind. I liked the application of the activity guide because it was easy to be studied, even I was just at home)”

Student 30: “Yes, because of that, I learnt on how to study by myself.”

On a focus group discussion, the students approved that one of their significant learning experiences was overcoming challenges to study. The students’ statements in studying indicate that the students also encountered challenges and were able to study autonomously, resulting in a more meaningful mathematics learning experience.

In general, the study results recommended the necessity for instructional materials, learning model, teaching approach, and methods that communicate growth mindset messages. Findings of the study propose that the application of the 5Ps learning model provided the students with necessary learning experiences that develop a growth mindset in mathematics. However, the study is limited solely to the participants included in the study; a larger sample is required for more generalizable results.

Conclusion

The implementation of the 5Ps learning model in teaching mathematics significantly affects students' mindset in mathematics, while conventional teaching does not significantly affect students' mindset in mathematics based on the findings of this study. Specifically, the application of the 5Ps learning model possesses a significant large effect on enhancing students' growth mindset in mathematics. The students manifest a growth mindset in mathematics by presenting courage in overcoming challenges in learning. There was an emphasis on the teaching and learning efforts that require the teacher's positive attitude and growth mindset in mathematics. Researchers could examine using the 5Ps learning model in teaching other learning areas and with larger samples to develop students' growth mindset.

Acknowledgements

The study recognized the efforts of the students, parents, observers, teachers, and school heads involved in the study for their participation and cooperation during the implementation and data gathering. It also recognizes the Department of Science and Technology for the financial support to make this study into reality and to the Department of Education for the approval to conduct the study in the school.

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RESEARCH ARTICLE 10

DESIGNS MATTER: Delivering Information Sources for Tourism

Margie A. Nolasco & Jonathan Dela Cruz

Asia Pacific Journal of Multidisciplinary Research, 4(4), 69–74

Original publication: 2016

DESIGNS MATTER: Delivering Information Sources for Tourism

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Asia Pacific Journal of
Multidisciplinary Research

Vol. 4 No.4, 69-74

November 2016

P-ISSN 2350-7756

E-ISSN 2350-8442

www.apjmr.com

Date Received: July 8, 2016; Date Revised: September 1, 2016

Abstract - Tourism has benefits not just for travelers, but also to the local economy. Since, Bicol Region has natural and cultural attractions; it is a potential travel destination in the country. Technology in delivering information sources played vital role for the success of the tourism industry in the Region. This allows travel enthusiasts to get more information about various tourist attractions. This paper analyzes the effectiveness of delivering information sources such as web advertisement and desktop publishing for tourist promotion in the Bicol Region. Specifically, it determined the status of tourism, and identified common forms of promotions for tourism development. The study adopted mixed method of research. This method was utilized to confirm and validate findings. Interviews and focus group discussions were used to gather data from the respondents of the selected Local Government Units, Department of Tourism, Travel Agencies and Hotel Agents in the Region. Based on the findings, of the total foreign visitors in the country, only 9.14% visited Bicol Region in 2014. That is why, domestic tourist showed high percentage against foreign visitors with 25.7%. Brochures with EZ maps as most commonly used desktop publishing materials and websites and social media for web advertisement. Thus, there is a need to reevaluate promotional activities by the DOT and other agencies. Adoption suggestive features for creative desktop publishing materials and web services should be considered to increase tourist visitors in the Region.

Keywords: tourism, promotion, desktop publishing, web, travel destination

INTRODUCTION

Tourism industry is another source of income for Bicol Region. One of the government agencies important to the success of tourist promotion is that of Local Government Units (LGUs). These LGUs play major role in community development, address community's problems and concerns, enforce policies, hold influence over their communities, and provide the links between the people and government, [1]. Provincial LGUs have the capacity to deliver sources of information from the different tourist destinations in the region to the different parts of the world. Technology shows a primary role in tourist promotion. It allows people to get more information about various tourist destinations and cultures. Its natural and cultural attractions of Bicol can be potential travel destinations in the country. Among the more popular sites are the gentle "butanding" whale sharks of Donsol, the "perfect cone" Mayon Volcano of Albay, the popular Cam Sur Watersports Complex (CWC) in Camarines Sur and other amazing and pristine tourist destinations. There are also a lot of fiestas and festivals in the Bicol Region happening in

the year, most fiestas and festivals in the region are religious in origin and Filipino hospitality is more evident at festival time. These beautiful nature, culture and preserved traditions seek to boost tourism, expand business and provide livelihood opportunities that have positive impact to the tourism industry and to the local economy.

The source of information about a specific destination is an important means of promotion for the tourism industry [2]. The sources of information for various tourist destinations like desktop publishing (brochures, flyers, and the like) and web advertisement (websites, social media and the like) play its vital role on the success in the Region's tourism.

Recent reviews indicate that as the tourism industry matures it becomes smarter, more adaptable, and takes its own trajectory by departing from the institutional norms of non-tourism organizations in the community [3]. Thus, tourism can be an option for the region's present economy because foreign arrivals are increasing. It is not just from its pristine tourist

destinations, LGUs could also be permanently sustained income-generating community-based cultural programs by means of institutionalization of cultural funding [4]. It is a way of promoting tourism in some parts of the world. Moreover, potential travellers have limited knowledge about the attributes of a destination which they have not previously visited [5]. For this reason, information sources like desktop publishing materials and web services in tourist destinations are likely to be the representations of what that place has to offer. With some deals and discounts coming from hotels, travel agencies and airline companies and on most cases which leads to a form of marketing. However, local governance structures, power relations, and stakeholder linkages that include processes on planning and tourism [6] should be regarded of it.

OBJECTIVES OF THE STUDY

This paper analyzes the effectiveness of delivering information sources for tourist promotion in the Bicol Region. Specifically, it: a) determines the status of tourism in terms of promotion; b) identifies common forms of delivering information sources; and c) analyzed their effectiveness for tourist promotion. This can provide as an opportunity to get, keep attention and allow travel enthusiasts to get more information about various tourist attractions.

MATERIALS AND METHODS

The study adopted descriptive-evaluative design of mixed methods of research [7]. Two different methods were utilized to confirm, validate or corroborate findings in analyzing the status of tourism promotion and the effectiveness of delivering information sources such as web advertisement and desktop publishing as tourist promotion in the Region for the year 2014-2015.

Study Area. "Bicolandia" is made up of the provinces of Camarines Norte, Camarines Sur, Albay, Sorsogon, Catanduanes and Masbate. Since, Bicol is one of the Philippines' best-known tourist destinations; this will give benefits not only to the big investors but also the community dwellers where the tourist spots are located. This provides more opportunities for employment and business ventures. The Cam Sur Watersports Complex (CWC) which attracts groups of water sports enthusiasts from all over the world and Caramoan National Park are found in the Province of Camarines Sur. That is why

Camarines Sur has gained the biggest domestic and foreign arrivals. Naga City and Legazpi City has gained 2nd and 3rd place for hosting numerous visitors of the most beautiful places in the neighboring provinces. A home of majestic structure of Mayon Volcano in Albay got 7.8% with 77,895 visitors. This was followed by Catanduanes, Masbate City and Camarines Norte where its eastern part of it has unspoiled beach- the Calaguas Island which has clear blue waters and white sand Sorsogon City and Masbate, the ranch capital in the country and Iriga City the City of Crystal Clear Springs got the lowest tourist visitors [8].

Population and Data Collection. The data and information of this study was generated from the responses of the selected 96 domestic tourists and 33 foreign tourists in Bicol Region through the use of convenient sampling. The data and information were collected using a questionnaire-checklist to the 129 domestic and foreign tourists during their actual visits to the selected tourist spots in Bicol Region. The data and information were collected using a questionnaire-checklist to the domestic and foreign tourists. The questionnaire was composed of two parts the first part was the profile of the respondents and the second part were the series of questions aimed to determine the status of tourism and problems encountered in terms of promotion; identify common forms of delivering information sources; and analyze their effectiveness for tourist promotion.

A qualitative method was utilized on data gathered through Interviews and Focused Group Discussions (FGDs) with selected Provincial and City LGUs, DOT focal persons, travel agencies and hotels agents. These were conducted concurrently to validate quantitative results used as bases for generalization of research outcomes; hence, mixed method of data collection was obtained. The review of related documents was also considered. Data gathered were statistically interpreted using frequency and percentage. They were analyzed and presented in graph and tabular form.

RESULTS AND DISCUSSIONS

Status of Tourist Promotion in the Region

Bicol is a best-known tourist destination in the country. This region can be a right place for adventurers, because of its volcanoes, beaches, caves, lakes and parks. It is also rich in culture evident the different festivals year round. That is why the tourism

industry can be the region's best pursuit for economic growth. Moreover, employment opportunities in the tourism industry [9] are catered to residents within the vicinity. Hence, it is not only LGUs and the service industries (transportation and hospitality services and entertainment venues) which will benefit from it, but also the community as a whole. Since, the market size of the tourism industry expands from the increase in the number of visitors.

Delivering information sources in tourism industry suggest an important role in the promotion and marketing of destinations. The Provincial and City LGUs in the Region have all the control of all promotional activities in their respective localities, hosting cultural activities, manufacturing the brochures, leaflets and foster to promote the place. Likewise, the Department of Tourism (DOT) and Department of Trade and Industry (DTI) are the two agencies that support the activities of the LGUs in tourism promotion. It is done by hosting and recommending representatives to the different trainings and seminars to the tourism focal persons, and recommending representatives to attend tourism expo. While DTI helps the local LGUs and native products manufacturers in promotions.

Results of interviews reflected the reasons why foreign tourists chose the Region for a visit, it is either exploring the area, discovering its culture, to relax and do business. According to them, they are also entertained by friendly people and great food. And still, word of mouth is more effective than other types of marketing [10]. Since, there are a lot of Bicolanos who worked and have relatives in other countries, this can have actively influenced or encouraged more tourists to visit the place. Americans contributed to the biggest arrivals in Bicol in 2014 with 104,961 visitors for a share of 35.1% to the total foreign tourist arrivals [11].

Tourists' destination is dynamic and continuously evolving, of particular importance are the impressions made upon arrival and departure, as they are powerful determinants of post-trip images [12]. It is unfortunate, of the total international tourist visited the country in 2014 for the figure of 3,267,542 only 298,827 or 9.14% visited Bicol Region in 2014 [13].

Problems in Bicol Tourism. Based from the interviews and FGDs, it showed that there are many problems in tourism industry that need to be resolved: of a) information dissemination, b) 3 A's of Tourism (access amenities and ancillaries), and c) Fund

Sources and Supports of Other Agencies d) Strategies in delivering information sources. The delayed and cancellation of flight/travels without further notice from the management is one of the problems encountered by the tourists who visited in the region. Since, transportation plays an important role in the travel experience of a tourist, delays and cancellations which lead to waste of time and energy can affect their post-travel evaluation. Although the airlines companies are not in control of some of the hitches like climate change or weather conditions but at least the passengers should be informed ahead of time. Few agencies for both private and public were actively participating tourism promotion activities. Accommodation services of tourist destinations in Bicol are only open during peak seasons and decent Hotel accommodations in Bicol are much expensive than other Asian countries.

The scenic spots and culture are not just some of the things that would add to the success of tourism industry but most importantly it is the visitors' enjoyment of the visit. That is why, travel agencies, airline companies, hotel owners and LGUs in the region should consider ways to attract tourists by their collaborative efforts in the active involvement in tourism promotion. Moreover, tourist time is valuable, most likely finest accommodation be provided by hotels/hostel/inns in the cities nearby or within the popular tourist destinations in the Region. Facilities from the service industries also should competitive with both national and international market.

Delivering Information Sources

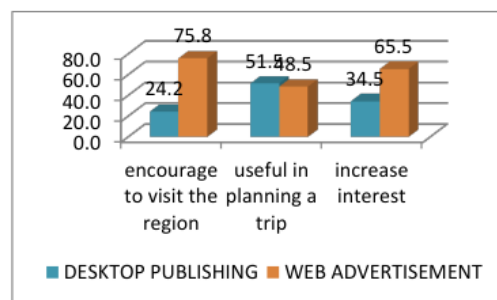


Figure1. Common forms of delivering information sources for tourism.

Common Forms. Social media are increasingly relevant as part of tourism practices affecting

destinations and businesses [14] and are playing an increasingly important role as information sources for travellers. The extent to which social media appear in search engine results in the context of travel-related searches [15]. Thus, the power of internet and social media in promoting tourism has great impact to the region's tourism industry. As shown in figure 1, among 129 tourist, 75.8% agreed that web advertisement, "encourages to visit the region" ; "increases interest of visitors " with 65.5% in contrast with desktop publishing with 24.2% and 34.5% respectively

It is normal for some foreign or local tourists to use the internet search engine for travel planning. It is done by just entering in the search engine, keywords on the information about destinations. This was further validated during the interview. Because of wide range of coverage to interact with the web through phones, tablets, TVs, and other gadgets, websites and applications are much accessible to people compared to desktop publishing because people can easily navigate the place, book hotels and even interact with the web. However, desktop publishing was found useful in planning a trip compared to web advertisement. The region has an on-line promotion to actively promote emerging tourist destinations, the nagax.com, and other sites. This confirms the growing importance of online tourist promotion and has been significant in the region's tourism industry. Nevertheless, these innovations and sudden change in technology may provide challenge not only for the tourism planners but also for tourism industry as a whole.

Common Forms for Desktop Publishing Web and Advertisement. Table 3 shows the summary results of delivering information sources for tourism and the other strategies made by tourism industry in Bicol Region. This was done using Focus Group Discussions (FGDs) and interviews with LGU's travel agencies, printing industries and Department of

Table 3. Common Forms for Desktop Publishing Web and Advertisement

Desktop Publishing	Web Advertisement
Brochures with EZ maps	Websites
Flyers	Social Networking
EZ maps	(Facebook, Twitter, And
Posters/Tarpaulin	Others)
Billboard	

It was found out that "brochures" and "websites" are the commonly used forms of promotion in Bicol. Every Provincial Local Government Unit (LGUs) produces their own brochures with EZ map in promoting tourist destinations like beaches, wildlife parks and others. Posters/Tarpaulin, leaflets, billboards and other forms are also used by some tourism agencies, depending on the demand of the events and activities. Other strategies made by the Provincial LGUs were travel packages, travel tour expo, tourism fairs, summits, television ads, radio ads, hosting conferences and competitive activities. It was found effective in promoting the Region. But according to some respondents, still the unpaid form of tourist promotion and one of the most credible forms of advertising is the word-of-mouth since a person puts their reputation every time they make a recommendation.

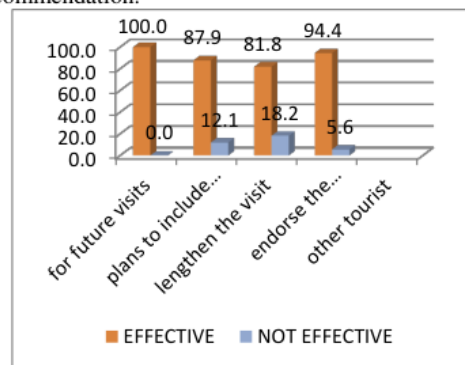


Figure 2. Delivering information sources in Bicol Region extent of effectiveness.

Extent of Effectiveness

The use of online sources of information to assist in the travel planning process is now well entrenched with prospective travellers [16]. Shown in figure 2 are the results of the extent of effectiveness of the different delivering information sources in Bicol Region (web advertisement and desktop publishing) for tourist promotions. They are "Effective" for tourists' future visits (100%); delivering information sources in the region are "effective" for their plans to include the region in their visits (87.9%); lengthen their visits (81.8%); and endorse the region to other tourist (94.4%). It maybe because, search engines likely direct travellers to social media sites and has its growing importance in the tourism domain [17]. The results imply that, web promotional activities have

been significant in the region's tourism industry. Fascinating attractions and culture have impact in increasing foreign arrivals in the region and making it a tourist hotspot in the Philippines. It is given that the web advertisement can effectively influence travellers than any other traditional forms of tourism promotional activities. Ultimately, web advertisement has positive impacts and potential to influence the tourists' decisions on visiting the region.

Proposed creative delivering information sources

Title: CREATIVITY BEHIND TECHNOLOGY:
An Innovative Delivering Information Sources For Tourist Promotion

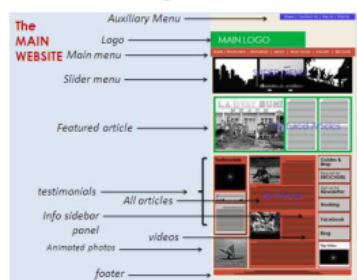
Rationale:

Majority of modern tourism websites have the same features, tourism implementation and promotion but then there are certain trends that have become so mainstream. Deliveries of websites and desktop publishing will vary based on the classifications of tourist from unconventional designs and layouts to full-featured user-friendly sites. This proposed website, entitled, **CREATIVITY BEHIND TECHNOLOGY: An Innovative Delivering Information Sources for Tourist Promotion** is an interconnected webpage that has features which allows user to navigate freely in the site and the clicked-interest or pages that stored for future sending of tailored-cut newsletter on his email are promotional factors which give positive impact to the tourism industry in Bicol.

Objectives:

Provide opportunities to increase tourist visitors in the Region, specifically, it will be able to:

- Address the issue of tourism industry;
- Lengthen tourist visits in the region; and
- Endorse the region to other tourists.



Template 1. Multi-site Structures and Navigation

Table 4. Special Features for Creativity Behind Technology Website

Features	Description
Main Menu	A top bar which consists a group of major options available in the website
Main Logo	Recognizable and distinctive information in a form of either pure graphics or composed of the name of the organization in a stylized way or interpreted with a unique symbol
Auxiliary Menu	An optional menu consisting links for SHARE, CONTACT US, LIKE USA, and FIND US
Banner	Clickable graphical advertisement linked to an assigned page describing and discussing an event or story called article. These crawling images may be in a form of taken shots or graphics which symbolize the article
Featured Article	A Special report or discussion of a person, event, an aspect of a major event, or the like, putting an emphasis and special interest commentary abounding with details that makes for pleasurable reading.
Testimonials	These are contents contributed by former clients for sharing their experiences they had during the event. Testimonials may be in a form of video, audio, and posted text messages.
All Articles	Compilation of various web documents written for a purpose of defining and describing a certain event. Aside its text, these may also consists of other web contents such as images, videos and audio recordings.
Information Side Bar Panel	Clickable buttons consisting links to Guides and Map, Request for Brochure, Sign-up for Newsletter, Booking, Facebook, and Blog.
Videos	Randomized links from various trip videos.
Animated Photos	Randomized images from taken photos from various events, places, activities, and the like.
Footer	A small section at the bottom of the page often used to display company data or copyright information

CONCLUSION AND RECOMMENDATION

Based on the findings, of the total foreign visitors in the country, only 9.14% visited Bicol Region. Camarines Sur as famous tourist destination in the Region Brochures with maps as most commonly used desktop publishing materials; and social media for

web advertisement. Web advertisement was used to encourage tourists to visit the region while desktop publishing is useful in planning a trip. Moreover, web advertisement and desktop publishing are effective in tourist promotion. Thus, it may be recommended that the region's tourism development policies should be revisited for an effective sustainable tourism program. A developed coordinated tourism strategy should be strengthened that identifies the key priorities within the region. There should have an adequate funding support for an internationally competitive tourism promotion, and adoption of a creative delivery of information sources for tourist promotion should also be considered to increase tourist visitors in the region.

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RESEARCH ARTICLE 11

Enhancing Mathematics Learning by Integrating Growth Mindset Principles in Ninth-Grade Supplementary Materials

Christian R. Repuya & Jedh Esterninos

Southeast Asian Mathematics Education Journal, 12(1)

Original publication: 2022

Enhancing Mathematics Learning by Integrating Growth Mindset Principles in Ninth-Grade Supplementary Materials

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Abstract

This paper determined the supplementary materials in ninth-grade mathematics which may be enhanced to integrate growth mindset principles to improve students' procedural fluency and foster their growth mindset in mathematics. This study employed a descriptive-developmental method by administering a quasi-experimental design and mixed-method research approach to determine the research questions. The respondents in this study were the 60 ninth-grade students at a state secondary high school in the Philippines. The study implemented the validated researcher-made procedural fluency test and growth mindset questionnaire in determining students' performance in procedural fluency and mindset in mathematics, respectively. Thematic analysis was employed to investigate students' responses in Focus Group Discussions (FGD), informal interviews and learning journals in scrutinising the learning experiences and mindsets of the students. Findings displayed that the supplementary materials which can be developed in incorporating growth mindset principles were motivational activities, reflection activities, and instructional videos. Utilising the developed supplementary materials elevates students' procedural fluency. It influences students to shift from fixed mindsets to growth mindsets in mathematics by providing them with significant learning experiences that help students enhance a growth mindset. Furthermore, the implementation group performed better than the comparison group, particularly with developing growth mindsets. The study results are limited to the participants encompassing; similar research employing the developed supplementary materials to other learning areas with a larger sample is recommended for more generalisable results.

Keywords: growth mindset in mathematics, motivational, procedural fluency, reflection, instructional videos

Introduction

Studying mathematics is tremendously crucial in people's lives. Mathematics education begins in the early stage of education. Its objective is to assist students acquire the significance of mathematics applications in the real world by enhancing their cognitive ability to recognise forms, patterns, and relationships. However, despite its significance, mathematics is still the least preferred and hated subject among students in general, and encourages for fewer students than other subjects. It is caused by the students who perceive mathematics as a complex subject, particularly following instructions. It results in difficulty obtaining the subject and trouble recalling its equations and methods to discover a solution to a problem (Gafoor & Kurukkan, 2015).

Correspondingly, students who possess a negative attitude towards their teachers and mathematics also perceive it as boring, and they are not encouraged (Mohapi, 2015). Enjoyment and attitude in learning mathematics significantly determine students' performances. Furthermore, the factors influencing the students to like or dislike mathematics encompasses students' social-psychological, environmental, instructional, and abilities

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factors. Moreover, the teacher's instructional strategy, institutional sources, weak understanding and evaluation approaches, and failure in comprehending directions are the factors of failure to pass mathematical examinations (Mazana, Montero, & Casmir, 2019).

In the Philippines, the international examination results in the Program for International Student Assessment (PISA) 2018 also presented a low growth mindset among students (Organization for Economic Co-operation and Development (OECD), 2019).

The PISA 2018 (OECD, 2019) results revealed that only 19% of students in the Philippines attained level 2 or higher in mathematics. Only 31% of students in the Philippines possessed a growth mindset. As a result, the Philippines performs low in the PISA examination, with an average score of only 350 points in mathematics, science, and reading during School Year (SY) 2018-2019, which place them in the rank 77th out of nearly 80 nations (OECD, 2019).

Unfortunately, the National Achievement Test (NAT) results formulated this global performance at the local levels. In the 2012 NAT, the Philippines performed low, with a Mean Percentage Score (MPS) of only 46.37 in mathematics. The enhanced performance was not acquired compared with the past years (47.82 in 2006 and 50.7 in 2005) and an overall rating of 48.57 during SY 2011-2012. This dilemma in mathematics paused threats to the future of mathematics education.

This evidence indicates that the students are not motivated and own a low interest in learning mathematics because they possess a low growth mindset. The students believe that learning mathematics is complicated as they own low procedural fluency. Procedural fluency refers to a student's understanding of procedures, as well as when and how to employ them correctly, and also the ability to administer procedures flexibly, precisely, and efficiently (Inayah, Septian, & Suwarman, 2020).

In response, the Department of Education (DepEd) (2020) encourages teachers to design lessons, learning materials, and instructional materials to assist students become motivated and have elevated understanding of the topics. Mendoza, Caranto, and David (2015) recommended that supplementary materials as integrating instructional videos effectively acquire the student's interest. Integrating instructional video into teaching/learning is a method in teaching which utilises videos that allows teachers to deliver lessons and encourage students through video recordings.

Gieras (2020) asserted that designing engaging instructional videos which encourage interactions and engagement to corroborate students' learning can be a very well effective medium for assisting instruction in remote, hybrid, and flipped or blended learning conditions. Moreover, Harackiewicz, Smith, and Priniski (2018), when students improve their interest in studying mathematics, their motivation in learning is also enhanced.

In her article, Campbell (2017) argued that success necessitates students to engage in the individual growth process. She highlighted on how difficult it might be to be open in producing incorrect and altering course all the time. It is normal to be involved to what we believe works and what we are accustomed to. She emphasised that in establishing a growth mindset, students should educate themselves to identify "deficient" as a shortfall in their learning or experience rather than a weakness in their capability. Dweck (as cited in Boaler, 2013) corroborated that intelligence and smartness could be acquired, and that brain grows from training with a growth mindset.

Conley (2014) implemented a growth mindset when providing students feedback, elaborating that praising them for intelligence made them less willing to pursue educational opportunities because they are anxious about losing their “smart” identity if they experienced low. Furthermore, because avoiding academic risks entails avoiding learning, applauding students undermines their academic achievement. The researcher employed the power of the word “yet” associated with a growth mindset. For instance, in praising students, “your sentence structure does not yet match the tone you are attempting to achieve”. The word “yet” accepts negative comment while at the same time conveys confidence that the students receive shortly (a teacher as this one possesses a growth mindset).

In addition to giving feedback, allowing students to perform reflective learning activities help them aware of their performance. In their study, Weng, Puspitasari, Rathinasabapathi, and Kuo (2021) defined reflective learning as activities in facilitating learners’ reflection upon their learning experiences. The findings of their study recommend the significance of reflective learning to enhance students’ recognition of asking and assessing their learning in the class.

Furthermore, Berger (2017) asserted that students are able to elevate the courage to encounter educational and life challenges. He cited one of the secondary schools, which has advanced academic courage in the students. As a result, 98% of their students graduated on time, and all of the students have been admitted to university.

The previous studies were beneficial in conceptualising the present study. Compared to the previous studies, the present study integrates growth mindset principles in the supplementary materials, which become the motivational activities, reflection activities, and instructional videos, that are not specifically implemented in the studies cited. Moreover, based on the literature and studies displayed, there is a crucial need to conduct this study to enhance supplementary materials in accommodating growth mindset principles to enhance students’ mindset and procedural fluency in mathematics.

The study was anchored on the following theories. The primary theory of this study is the (1) Mindset Theory (2006) and was corroborated by (2) Constructivists Theory (McLeod, 2019) and (3) Scaffolding theory of Lev Vygotsky (McLeod, 2019).

Carol S. Dweck is the author of the Growth Mindset Theory. She explained that a mindset believes in oneself, and one’s basic qualities. An individual with a fixed mindset believes that traits like intelligence, creativity, and ability are predefined and finite. These attributes are so established in persons with fixed mindsets that whatever they lack, they remain to be inadequate.

A person with a growth mindset, on the other hand, believes that their natural talents were further strengthened via hard work and dedication. These intrinsic traits are merely the beginning; the results of success from hard work, study, and perseverance.

Dweck employed a school setting as an example who explained that fixed and developing mindsets emerge differently. Students with a fixed mindset regulate image above all and, as a result, disregard the essential learning opportunities if performing poorly or admitting mistakes is required. In the classroom, cognitivist teaching approaches strive to help students assimilate new material into their existing knowledge while also make them produce the required modifications to their current intellectual structure in accommodating the new knowledge.

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According to the scaffolding theory, scaffolding involves adjusting the amount of assistance to the intellectual abilities of students. During a teaching session, the extent of coaching was modified to fulfil the student's potential level of performance. When a student experiences difficulties with a task, further assistance is provided, and as the student progresses, less guidance is performed.

The objective of this study is to enhance students' mathematics learning by integrating growth mindset principles in ninth-grade supplementary materials in one of the junior high schools in the Philippines. In particular, it examined the supplementary materials in ninth-grade mathematics which may be enhanced to integrate growth mindset principles. Moreover, it was also performed in determining the effects of employing the ninth-grade supplementary materials with growth mindset principles integration in enhancing students' procedural fluency in mathematics and fostering their growth mindset in mathematics.

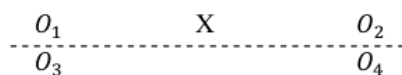
This study is deemed essential to students because the findings would convey messages that mathematics can be learned by all individuals who are able to learn and appreciate mathematics and that their ability is not fixed. For teachers, the findings of the study would assist them appreciate the implementation of supplementary materials promoting a growth mindset through motivational activities, reflective learning activities, and utilisation of instructional videos that make students encouraged, responsible, and possess a robust growth mindset in mathematics. In improving growth mindset and procedural fluency among students in mathematics, the school administrators, curriculum designers, and textbook writers may consider the study's findings in formulating programs, designing curriculums, and selecting a framework for writing textbooks respectively.

Methods

Research Design

The study employed the descriptive-developmental method using a quasi-experimental design. The study also utilised the mixed-method approach of research inquiry. The implementation group applies the innovation to determine the effect of utilising the ninth-grade mathematics supplementary materials with growth mindset integration on students' procedural fluency and mindset in mathematics. The comparison group was implemented for the comparison of results which incorporated the textbook and lesson plans provided by the department of education without the supplemental materials.

Below is the study's design diagram, where O_1 and O_2 are the pretest and posttest of the implementation group, respectively. X is the intervention (developed supplementary materials integrating growth mindset principles). Meanwhile, O_3 and O_4 are the pretest and posttest of the comparison group, respectively, without the intervention:



Respondents

The respondents of the study were purposively selected two classes of one of the public secondary high schools in the Philippines, SY 2020-2021. Purposive sampling is a technique

in which the researcher arranges criteria to select members of the population to be in charge as respondents of the study (Dudovskiy, 2017). The researcher in this study selected the grade 9 students as it was the first level after the middle school, which is appropriate for the study, and they became the next group who conducted the NAT. It is also because, during mid-school classes, there is a rise in an imbalance of mathematics teaching (Sun, 2015).

In selecting the two groups, the students' previous mathematics grades were examined to ensure no significant difference between the student's initial performances in mathematics and were comparable. The implementation group and comparison group were established through a toss coin. Each class comprised of 30 students, 17 male and 13 female in the implementation group, and eight male and 22 female in the comparison group. The researchers have explained the respondents that they were purposively selected, and informed consent was secured. They also discussed the role of the respondents and other ethical details. Moreover, the confidentiality of respondents' scores in the procedural test, mindset questionnaire, and other responses was assured.

Research Procedure

A letter of asking permission to conduct the study was created and proposed to the Department of Education's Schools Division Superintendent and the school supervisors for approval. The researchers began preparing, developing, and validating the data collection instruments after receiving the approval. The group of students in O_1 (implementation) and O_3 (comparison) was provided a pre-test and post-test in 30-item researcher-made test in mathematics to identify their procedural fluency. Before the intervention, a pre-test (O_1) was administered to the group, then a post-test (O_2) was conducted after the intervention. The difference between the pre-test and post-test ($Q_1 - Q_2$) was employed to ascertain whether there is a change or gain due to supplementary materials of integrating growth mindset principles (intervention, X).

Quantitative data encompasses students' responses to the mindset questionnaire and feedback on their journals, and informal interviews regarding their experiences during the supplementary materials implementation. The students' mindset scores from the mathematics interview schedule questionnaire were investigated by utilising a quantitative method. Furthermore, journal and informal interviews were administered to demonstrate the improvement of a growth mindset among students in applying the supplementary materials. The data gathered were then accommodated and organised for presentations and analysis. The researchers prepared the research report after the data were arranged, analysed, and interpreted.

Research Tool and Analysis

The study utilised the adopted validation guide from the DepEd as the instructional materials evaluation tool in validating the developed supplementary materials along with their features (DepEd Naga City Division Order No. 441, series of 2019). The researcher demanded the panel of experts to portray their opinion on the statements and item regarding the features of the supplementary materials by incorporating comments and suggestions for improvement.

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The instructional material evaluation tool possesses a five-point scale with the following descriptive interpretation: 4.51-5.00 (outstanding), 3.51-4.50 (very satisfactory), 2.51-3.50 (moderately satisfactory), 1.51-2.50 (poorly satisfactory), and 1.00-1.50 (not satisfactory). The supplementary materials were assessed in three components in particular: mathematics content, features, and technical aspects.

Along with the mathematics content, the supplementary materials were examined concerning the consistency to learning competencies, objectives and accuracy of the content. Along with the features, the evaluation process concentrated on the supplementary materials' features and appropriateness to the objectives as reflective learning activities, motivational activities, and instructional videos. Finally, along with technical aspects, the supplementary materials were evaluated in regarding the application of stimulating graphics, utilising colours pleasing to the eye, readability, and organisation of texts, consistency in the utilisation of font, colours, and design, presentation of the cover page, and the easiness to reproduce.

The validated procedural fluency test was employed for pre-test and post-test in identifying students' procedural fluency. It incorporates the lessons established for the 4th quarter of the SY 2020-2021 based on the Most Essential Learning Competencies (MELCs) under the K-12 Curriculum of the DepEd. The procedural fluency test was designed with a table of specifications to ensure that the test items were equally distributed among the topics and learning competencies encompassed in the test.

The researcher implemented the mindset questionnaire of Dweck (2006) during interview schedules to collect students' pre- and post-scores in mindset in mathematics. The questionnaire comprises 20 statements illustrating growth or fixed mindset (questions directed to mathematics performance). The respondents responded with the scales of strongly agreed, agreed, disagreed, or strongly disagreed with the statement. The statements were assigned point values. If the statement was a fixed mindset statement, the point values were: 0 points for strongly agree, 1 point for agree, 2 points for disagree, and 3 points for strongly disagree. If the statement demonstrated a growth mindset, the point values were: 3 points for Strongly Agree, 2 points for agree, 1 point for disagree, and 0 points for strongly disagree. The interpretation of the total mindset scores comprises 00-20 (strong fixed mindset), 21-33 (fixed mindset with some growth ideas), 34-44 (growth mindset with some fixed ideas), and 45-60 (strong growth mindset).

The fixed mindset statements encompass, "Some people are good in mathematics and kind (patience in mathematics), and some are not – it is not frequently that people change". Meanwhile, the growth mindset statements incorporated a statement like "all human beings are capable of learning mathematics". For instance, supposing a student's mindset survey score declines between 00-20. In that case, he possesses a strong fixed mindset which implies his belief that mathematics ability is fixed and cannot be learned through effort, as he responded to the questions in the mindset survey. Furthermore, if a survey score of students' mindsets descends between 21-33, he owns fixed ideas about mathematics ability but also believes in any other method that mathematics can be learned through exercise, as he responded to the mindset questions.

Unstructured interview, focus group discussion questionnaires, journals, and outputs were also considered to corroborate the findings of the study through thematic analysis. Frequency

count was employed to calculate the number of occurrences of respondents' answers under the different questions and the number of students' correct responses in the mathematics researcher-made pre-test and post-test in procedural fluency. Moreover, it also administered to measure the number of students' growth mindsets based on the scale and interpretation.

The difference between the pre-test and post-test of the students on the procedural fluency exam was determining the application of the Mean Difference/Mean Gain method. The students' procedural fluency and performance levels were identified by utilising the percentage technique. According to the National Council of Teachers of Mathematics (NCTM) (2014), the ability to implement procedures precisely, efficiently, and flexibly; to transfer procedures to new issues and contexts; to generate and adjust procedures from other procedures, and to comprehend the moment of one technique or method is more appropriate to implement than the other is procedural fluency.

In this study, students' performance level in procedural fluency concerns on the student's scores on a 60-item procedural fluency multiple-choice test formulated and validated by the teacher, and answered by students in the pre-test and post-test. The performance level of the students was interpreted by administering the scale: 35 and below (very low mastery), 36-65 (low mastery), 66-85 (average mastery), 86-95 (moving towards mastery), and 96-100 (mastered).

Results and Discussion

The primary concern of this study is to enhance supplementary materials for ninth-grade mathematics with growth mindset principles integration which was expected to help students encourage and enjoy learning and possess meaningful learning while studying at home. The study's outcomes could serve as supplemental materials to corroborate mathematics teachers in teaching mathematics to enhance students' procedural fluency and mindset in mathematics.

The developed supplementary materials encompassed six lessons for ninth-grade mathematics, such as the six trigonometric ratios, the trigonometric ratios of special angles, angles of elevation and angles of depression, trigonometric ratios to solve real-life problems incorporating right triangles, laws of sines and cosines, and problems accommodating oblique triangles. Each lesson was anchored to the most essential learning competencies of the Ninth-Grade Mathematics Curriculum and adhered the policy on lesson planning of the Department of Education.

Five jurors subjected the developed supplementary materials to critiquing. The jurors provided their comments, suggestions, and recommendations to enhance each part of the lessons and supplementary materials. The developed lessons possess specific features in which the developed supplementary materials incorporate growth mindsets. These are motivational activities, reflective learning activities, and integration instructional videos to assist students enhance a strong growth mindset in mathematics.

Motivational Activities

Table 1 presents the integration matrix of the growth mindset principle through motivational activities in the developed supplemental materials for teaching ninth-grade mathematics. Motivational activities in every lesson were employed to make students more

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prepared. Each topic was associated with them, leading them to think about the growth mindset principles.

For instance, in lesson 1, along with the “Let’s start”, the students read the direction and employed the words in the box to complete the sentence. It came up with the phrases “I will do my best”, “I can perform more effort”, “I can learn from my mistakes”, “I can achieve my goals”, and “I can overcome challenges”. These phrases are concerning about the growth mindset that the students require to enhanced. According to Dweck (2006), if the students think that their success is based on hard work, learning, and training, individual possesses a growth mindset. In this activity, students will identify what they require to remember to more succeed the learning on particularly topic. In that case, the student can improve their growth mindset.

In lesson 2, along with the “Let’s start” part, the activity assisted the students develop their growth mindset in a method that they require to realise that for them to enhance their performance, they need to learn new things, welcome constructive feedback, discover creative solutions to solve a problem, elevate with practice, and train their brain. The activities in lessons 3 and 4, “Discovering a Solution to a Problem” and “Converting Negative to Positive”, may enhance the students’ growth mindset.

Table 1
Integration of Growth Mindset Principles via Motivational Activities

Integration of Growth Mindset Principles via Instructional Activities

Lessons	Activities	Description												
Lesson 1:	Challenge Yourself to Succeed	This activity was anchored on the growth mindset principle. This activity allows students to understand that our belief about intellectual abilities can be enhanced for us to be successful.												
The Six Trigonometric Ratios: Sine, Cosine, Tangent, Secant, Cosecant, and Cotangent	<u>Direction:</u> Use the words in the box to fill in the blanks 1. I will do my _____ 2. I can put in more _____ 3. I can learn from my _____ 4. I can achieve my _____ 5. I can overcome _____ challenges goals best mistakes effort	In this activity, students have discovered what they need to remember to be more successful in understanding the topic. Hence, the students are able to improve their growth mindset.												
Lesson 2:	Improve and Develop	This activity assists the students to be aware that there are principles that we need to follow to enhance our performance. The students matched the appropriate word from column B to complete the sentence to realise this.												
The Six Trigonometric Ratios of Special Angles	<u>Direction:</u> Match the appropriate word <table><tr><th>Column A</th><th>Column B</th></tr><tr><td>I can learn _____</td><td>a. solutions</td></tr><tr><td>I welcome constructive _____</td><td>b. practice</td></tr><tr><td>I can train my _____</td><td>c. new things</td></tr><tr><td>I can improve with _____</td><td>d. brain</td></tr><tr><td>I can find creative _____</td><td>e. feedback</td></tr></table>	Column A	Column B	I can learn _____	a. solutions	I welcome constructive _____	b. practice	I can train my _____	c. new things	I can improve with _____	d. brain	I can find creative _____	e. feedback	This part concerns on developing the students' growth mindset that knowledge is not fixed but can be improved.
Column A	Column B													
I can learn _____	a. solutions													
I welcome constructive _____	b. practice													
I can train my _____	c. new things													
I can improve with _____	d. brain													
I can find creative _____	e. feedback													

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Lessons	Activities	Description																						
Lesson 3: Angle of Elevation and Angle of Depression	Finding a Solution to a Problem <u>Direction:</u> Match the correct solution to a problem from column A to column B Column A  Column B 	The students matched column A to column B to get the correct solution to a problem or scenario. This activity focuses more on developing the students' growth mindset that there is no problem if there is no solution.																						
Lesson 4: Solving Word Problems Involving Right Triangles	Negative to Positive <u>Direction:</u> Convert the following negative thought to positive thinking. <table><thead><tr><th>Negative Thoughts</th><th>Your Positive Thoughts</th></tr></thead><tbody><tr><td>1. Mathematics is a very hard subject for me.</td><td>1.</td></tr><tr><td>2. I cannot solve any problems in Trigonometry concerning right triangles.</td><td>2.</td></tr><tr><td>3. I never understand the concept and process of solving problems in Mathematics.</td><td>3.</td></tr><tr><td>4. I think that my teacher does not care about my learning.</td><td>4.</td></tr><tr><td>5. I could not complete high school because there was a lot of homework and projects.</td><td>5.</td></tr><tr><td>6. I cannot go to college because it is very hard.</td><td>6.</td></tr><tr><td>7. I cannot study without the help of my classmates or my friends</td><td>7.</td></tr><tr><td>8. I think that I am not good at anything.</td><td>8.</td></tr><tr><td>9. I never do anything to succeed.</td><td>9.</td></tr><tr><td>10. I cannot achieve my dream and be a successful person.</td><td>10.</td></tr></tbody></table>	Negative Thoughts	Your Positive Thoughts	1. Mathematics is a very hard subject for me.	1.	2. I cannot solve any problems in Trigonometry concerning right triangles.	2.	3. I never understand the concept and process of solving problems in Mathematics.	3.	4. I think that my teacher does not care about my learning.	4.	5. I could not complete high school because there was a lot of homework and projects.	5.	6. I cannot go to college because it is very hard.	6.	7. I cannot study without the help of my classmates or my friends	7.	8. I think that I am not good at anything.	8.	9. I never do anything to succeed.	9.	10. I cannot achieve my dream and be a successful person.	10.	In this Activity, “Negative to Positive”, The students convert the following negative thoughts to positive thinking. This activity is more on elevating the students' growth mindset that for us to be successful in life, we require to practice converting negative thoughts into positive thinking. The students answered the following questions: 1. How did you convert the following negative thoughts to positive thoughts? 2. How can this activity assist you to be optimistic and motivated to learn?
Negative Thoughts	Your Positive Thoughts																							
1. Mathematics is a very hard subject for me.	1.																							
2. I cannot solve any problems in Trigonometry concerning right triangles.	2.																							
3. I never understand the concept and process of solving problems in Mathematics.	3.																							
4. I think that my teacher does not care about my learning.	4.																							
5. I could not complete high school because there was a lot of homework and projects.	5.																							
6. I cannot go to college because it is very hard.	6.																							
7. I cannot study without the help of my classmates or my friends	7.																							
8. I think that I am not good at anything.	8.																							
9. I never do anything to succeed.	9.																							
10. I cannot achieve my dream and be a successful person.	10.																							

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Lessons	Activities	Description
Lesson 5: Oblique Triangles: Sine Law, Cosine Law, and the application	You Can Do It. Trust Yourself <u>Direction:</u> Formulate your own motivational quotes that you can always remember to be a successful person someday. <u>Answer the following questions:</u> 1. How can this motivational quote help you in your study about this topic in this module? 2. What are the things you need to perform now to achieve your dreams? 3. From the quotes you have encountered in the previous modules, what quote do you like the most? Why and how will you apply those to grow and develop as an individual?	In this activity, the students generated motivational quotes that they can always remember for them to be a successful person someday. Hence, it helps the students to enhance their growth mindset.

This section is able to develop the students' growth mindset; hence, they need to realise that every problem, big or small, must possess a solution, and failure and mistakes are not bad things. The motivational activity in lesson 5 is "You can do it, Trust Yourself". In this activity, the students created motivational quotes that they can always remember to be a successful person someday. This section enhances students' growth mindset; thus, the students will realise that there is no other way to enhance themselves but by trusting themselves.

Briggs (2015) stated in his article that learning takes time and do not anticipate learning everything in one session. It indicates that the students need to exert efforts to learn and realize that knowledge is not fixed but can be enhanced. When students make a mistake or own a problem, they have not failed but they have learned instead. He recommended replacing the word "failing" with "learning" which can improve students' growth mindset. Furthermore, students should stop finding approval from others because when students prioritise approval over learning, they sacrifice their growth potential.

Reflective Learning Activities

Reflective learning was one of the features of the developed supplementary materials accommodated on the growth mindset employed in this study. Gray (2021) defined reflective learning as students' thinking about what they have learned in the classroom and how it is implemented into their individual life. It is a method of learning in which students reflect upon their learning experiences. Reflective learning also allows the students to reflect on their learning.

In this study, reflective learning concerns on the students' reflections in the lesson format which implement supplementary material attached on growth mindset principles and the approach employed in the development of the lessons. Table 2 presents the promotion of reflective learning, another feature of the developed supplemental materials for teaching ninth-grade mathematics.

Table 2
Promoting Reflective Learning

Lessons	Reflective Learning Theme	Description
1	"Success is not an accident. Success is a choice". – Stephen Curry (n.d.)	In this lesson, reflective learning was performed in the "Let's Reflect" part, in which the students reflect on their learning. The students reflect on the provided quotation, that is about being successful. This activity will motivate the students to study hard for the successful outcome.
2	"Learn everything you can, learn anytime you can from anyone you can – there will always come a time when you will be grateful for what you did" – Sarah Caldwell (n.d.)	The quotation about learning by Sarah Caldwell was employed to promote reflective learning. In the "Let's reflect" part, the students reflect on their learning and the provided quotation about the importance of learning. The students will realise that learning is essential. It also helps to improve the growth mindset of the students.
3	"Work to find solutions instead of always highlighting the problems". – picturequotes.com (n.d.)	The promotion of reflective learning in this lesson is on the "Let's reflect" part, in which the students reflect on the quotation about discovering a solution for a problem. It will also assist the students to enhance their problem-solving skills, accommodated to the growth mindset principles.
4	"Once you replace negative thoughts with positive ones, you will start having positive results" – Willie Nelson (n.d.)	In this lesson, reflective learning was introduced in the "Let's Reflect" part, in which the students reflect on their learning. The students also reflect on the provided quotation, which is about being positive. This activity will encourage students to study hard and avoid any negative thoughts.
5	"Trust yourself. You know more than you think you do". – Benjamin Spock	The quotation about trusting oneself by Benjamin Spock was administered to promote reflective learning. In the "Let's reflect" part, the students reflect on their learning and the provided quotation about the importance of self-confidence. The students will realise that trusting oneself is crucial in learning and achieving goals.

In the "Let's Reflect" part, the last part of every developed lesson, the students reflect on the provided quotations. For instance, in lesson 1, the quotation is about success by Curry (n.d) "Success is not an accident, success is a choice". The student reflected on this quote to encourage them to study hard for being successful. This part also allows the students to review and reflect on their learning and new understanding.

In this part, the students were also asked about what they have learned, the difficulties they experienced, what they learned from these quotes at each start of the lesson, and the way to apply the things they have learned to acquire their goals. As another part of their reflections, they were also asked to write their significant learning experiences to capture their significant learning experience during the conduct of the study.

Elias (2010) explained that students' reflections were identified as one of the top six activities to assist students to be successful. He asserted that students should formulate their goals, record the achievements, and show and share the learning with others.

Promoting reflective learning in lesson 2 was on the "Let's Reflect" part. The students reflected on the quote by Caldwell (n.d), which is "Learn everything you can, learn anytime you can, learn from anyone you can – there will always come a time when you will be grateful for what you did". In this activity, the students realised that learning was essential and help them enhance their growth mindset.

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Malec (2021) elaborated that continuous learning is vital because it assists students feel joy in life and elevate their productivity. When students realise the importance of learning, they will be encouraged and eager to learn. The students also reflected on what they did and learned from activity two and how it helped them prepare for the topic. The difficulties they have encountered in the lesson and how they solved it, how the concepts they have learned are applied in real life, and how it may assist them to achieve their goals.

The theme in lesson 3 was “finding a solution to a problem”. Problems in learning are frequently present, hence, the students sometimes do not understand what to perform. In this part of the promotion of reflective learning, the students reflected on the quotation about finding a solution to a problem: “Work to find solutions instead of always highlighting the problems” (picturequotes.com). It helps the students improve their problem-solving skills and promote growth mindset principles.

In lessons 4 and 5, the students reflected on the quotations about possessing positive thoughts and trusting themselves. One of methods for them to succeed is to be positive and trust themselves. As cited by Williams (2017), Dewey asserted that reflection was a tremendous significant part of learning. He advocates that reflective learning is not merely reading and obtaining knowledge. It is an active examination of learning from the information in accordance with the students’ learning experiences. The students need to think deeply based on what they have read and learned from the lesson. Then, they can implement the knowledge to their context. The implementation of supplementary material with its features makes learning meaningful to the students since they can reflect and freely express their selves about what they have studied. It also encourages learning transfer because students would easily identify the concepts as they reflect on their personal experiences.

Furthermore, the DepEd promoted reflective learning in the K to 12 Basic Education to provide a meaningful learning experience. Reflective learning allows learners to employ what they have learned and why they need to learn (Department of Education Order No. 21, series of 2019). Additionally, Briggs (2015) stated that if the students are allowed to reflect on their understanding at least regularly, they can enhance their growth mindset. Opportunities for reflection encourage the students to be motivated to learn and elevate their interest in learning.

Integration of Instructional Videos

Integrating instructional videos was one of the features of the developed supplementary materials encompassed on the growth mindset employed in this study. Any video displaying a procedure, transmitting knowledge, explaining a concept, or presenting someone how to accomplish something are classified as an instructional video. It means that it is a form of instruction utilising technology to convey knowledge to the viewers (Simon, 2012). According to Mendoza et al. (2015), employing instructional materials and integrating instructional video obtains the student's interest. It also helps the students to concern on the lessons.

Table 3 presents the developed supplemental materials featuring the integration instructional video teaching ninth-grade mathematics. Videos in each lesson were utilised as instructions that assisted students to comprehend each topic in mathematics and were

associated with them, improving their understanding and interest in mathematics.

In this study in lesson 1, the instructional video is all about the concept of the six trigonometric ratios, portraying the parts of a right triangle and illustrating the six trigonometric ratios. It also displays the method to identify the missing parts of the triangle and its application in real life. In lesson 2, the instructional video discusses about the “trigonometric ratios of special angles”. The students watched the video which portrays the concept of Trigonometric Ratios of Special Angles, discovering the missing parts of the triangle utilising special angles, and its application in real life. After watching the instructional video, they were writing what they had learned in their notebook and answered some questions associated with the discussion.

Table 3
Integrating Instructional Videos

Lessons	Instructional Videos	Descriptions
Lesson 1: The Six Trigonometric Ratios: Sine, Cosine, Tangent, Secant, Cosecant, and Cotangent	“The Parts of the Right Triangle”	This instructional video in this section integrated into the “Let’s Start” part, activity number 2, in which the students watched the video segment to assist them to recall the different concepts about a triangle and answered the following questions: 1. What are the parts of the right triangle? 2. What are the definitions of the parts of a right triangle? 3. Is it easy to identify the parts of a right triangle? Why? or why not?
	“The Six Trigonometric Ratios”	Another instructional video in this section also accommodated “Let’s find out” part, and they wrote the things they had learned from the video. The concepts of The Six Trigonometric ratios were further discussed.
	“Trigonometry – Application”	In the “Let’s apply” part, the students watched the instructional video and solve the provided worded problem about the six trigonometric ratios and answered the following questions: 1. Did you obtain the correct answer? How? 2. Is the problem easy to solve? Write the difficulties you've encountered if you have one? 3. If you were asked to make your trigonometric ratio problem, how would you make it?
Lesson 2: The Six Trigonometric Ratios of Special Angles	“Exact Trigonometric Ratios by Employing Your Hands”.	The instructional video in the “Let’s Start” part was on activity number 2. The students watched the video segment to help them remember the exact trigonometric values employing their hands. Then, they answered the following questions: 1. How did you feel after you watched the video? 2. Did employing the hand trick in finding exact trigonometric values make you easily compute the values of trigonometric ratio? 3. How could you utilise the trigonometric ratios hand trick in finding the unknown angles or sides of a special right triangle?
	“Trigonometric Ratios of Special Angles”	In the “Let’s find out” part, the instructional video in this part talks about the concept of Trigonometric Ratios of Special Angles. The students watched the video, and they wrote the things that they had learned.
	“Trigonometry – Application”	Another instructional video incorporates on “Let’s apply” part. The students watched the video about solving problems involving trigonometric ratios of special angles and solve the provided worded problems.

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Lessons	Instructional Videos	Descriptions
Lesson 3: Angle of Elevation and Angle of Depression	“Angle of Elevation and Angle of Depression”	The instructional video in this lesson was on the “Let’s find out” part, and it discussed about the concept of the Angle of Elevation and the angle of depression. This content discussed all the content. The students watched the video segment and wrote what they had learned. <u>Questions:</u> 1. Based on the video you’ve watched, what is the definition of angle of elevation? 2. What is angle depression? 3. What are the differences between the angle of elevation and depression?
	Clinometer (How to make and use)	The instructional video in this part was the video containing the way to create a clinometer. The students followed the steps in making a clinometer based on the instructions from the video, and then the students performed activity 4. In Activity 4, “Your Shadow”, students calculate the height of their friend and the length of his/her shadow. Applying the concept of trigonometric ratios, the students determined the angle of elevation from the ground to the sun.
Lesson 4: Solving Word Problems Involving Right Triangles	“The Scientific Calculator” and “Example Problem”	The instructional video in this lesson was about utilising the scientific calculator and solving problems incorporating the right triangle. The students watched the video segment about the example of problems involving right triangles applying the trigonometric ratios and wrote what they had learned.
Lesson 5: Oblique Triangles: Sine Law, Cosine Law, and its application	“Sine and Cosine Law: Finding the missing parts of an oblique triangle”. “Sine and Cosine Law – Application”	The instructional video in this lesson was all about oblique triangles. The students watched the video segment entitled “Oblique Triangles” Sins and Cosine Law: Finding the missing part of an Oblique Triangle, and afterward, they wrote the things they had learned. From the video, the concepts were further discussed. Another video on this part discussed about the application of Sine Law and Cosine Law. The students watched the video about Sine Law and Cosine Law–Applications and solved the provided worded problems.

There is an instructional video in activity 2, in which the students were watching the video segment entitled “trigonometric ratios shortcuts” to assist them remember the exact trigonometric values by employing their hands. The short video presents the way to memorise exact trigonometric values by employing the hand trick. The video helps the students easily compute trigonometric ratios’ values, and employ the trigonometric ratios hand trick in identifying the unknown angles or sides of a special right triangle. There is also a video about the implementation and how to solve problems regarding trigonometric ratios of special angles. This video displays the students how to solve problems involving trigonometric ratios of special angles.

In lesson 3, the instructional video in this lesson is on the “Let’s find out” part. It discusses about the “angle of elevation and angle of depression”. The students were watching the video segment about the “angle of elevation and angle of depression”. The video displays the way the angle of elevation and angle of depression is employed in solving word problems

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incorporating right triangles and application in real life. They were also writing about what they had learned from the video for their reflection and evaluation purposes. There is also a video about how to make a clinometer. The video teaches the students on how to make and utilise the clinometer to calculate the angle of objects.

After they have watched the video, an activity follows, which is activity 4. In Activity 4, entitled “Your Shadow”, students measured the height of their friend and the length of his/her shadow. Employing the concept of trigonometric ratios, the students examined the angle of elevation from the ground to the sun. Employing the clinometer, they could calculate the angles. After the activity, there are also questions that they require to answer as a part of the evaluation,

In lesson 4, the instructional video is on the “Let’s find out” part. It is all about solving problems encompassing the right triangle, utilising the scientific calculator, and employing concepts in the previous lesson to solve problems incorporating the right triangle. The students watched the video segment about example problems concerning right triangles utilising the trigonometric ratios.

In lesson 5, the instructional video is on the “Let’s find out” part. It was about oblique triangles. The students watched the video segment entitled “Oblique Triangles” sine and cosine law: discovering the missing part of an oblique triangle. There was also a video on the “Let’s apply” part. The video on this part discussed about implementing sine and cosine law. The students watched this video and solved the provided worded problems.

There are six lessons developed with instructional videos, that are the six trigonometric ratios, the six trigonometric ratios of special angles, the angle of elevation and angle of depression, solving word problems incorporating right triangles, and oblique triangles: sine law, cosine law, and its application.

Effects on the Students’ Procedural Fluency in Mathematics

Procedural fluency is the ability to implement procedures accurately, efficiently, and flexibly, to correlate procedures to different problems and contexts, build and modify procedures from the other ones, and recognise when one strategy or procedure is more appropriate. In developing procedural fluency, students should experience rationalising both informal approaches and general employed procedures mathematically, should establish and defend their choices of appropriate procedures and reinforce their knowledge and skills through the distributed practice (NCTM, 2014).

Employing supplementary materials anchored on growth mindset principles in the development of the lessons in ninth-grade mathematics allows students to enhance procedural fluency. Table 4 presents the pre-test and post-test results provided for students in the implementation group. It indicates that the mean scores of the students in the implementation group during the pre-test were all interpreted as very low mastery except for the fourth competency on solving real-life problems which encompass right triangles classified as low mastery.

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Table 4
Result of Pre-test and Post-test in the Procedural Fluency

Topics	No. of Items	Implementation Group					Comparison Group				
		Pre-test		Post-test		Mean	Pre-test		Post-test		Mean
		Mean	Interpretation	Mean	Interpretation	Gain	Mean	Interpretation	Mean	Interpretation	Gain
The six trigonometric ratios	4	0.97 (24.3%)	VLM	3.1 (77.5%)	AM	2.13	1.2 (30%)	VL M	2.2 (55%)	LM	1
Trigonometric ratios of special triangles	4	0.93 (23.3%)	VLM	1.9 (47.5%)	LM	1.27	1.1 (27.5%)	VL M	1.5 (37.5%)	LM	0.4
Angles of elevation and depression	7	1.37 (19.6%)	VL M	3.7 (52.9%)	LM	2.33	2.6 (37.1%)	LM	3.1 (44.3%)	LM	0.5
Solving real-life problems involving right triangles	3	1.4 (46.67%)	LM	2.3 (76.7%)	AM	0.9	1.4 (46.7%)	LM	1.9 (63.3%)	LM	0.5
The laws of sines and cosines.	9	2.37 (26.3%)	VLM	4.6 (51.1%)	LM	2.23	3.5 (38.9%)	LM	4 (44.4%)	LM	0.5
Solving problems involving an oblique triangle	3	0.6 (20%)	VLM	1.4 (46.7%)	LM	0.8	0.8 (26.7%)	VL M	1.2 (40%)	LM	0.4
Total	30	7.63 (25.5%)	VLM	16.87 (56.2%)	LM	9.24	10.67 (35.6%)	VL M	13.93 (46.4%)	LM	3.23

Legend: VLM – Very low Mastery, LM – Low Mastery, AM – Average Mastery, HM – High Mastery, VHM – Very high mastery, p^* tested at a .05 level of significance

Looking at the data, the learning competency “solving real-life problems involving right triangles” (46.67%) owned the highest performance level, while the lowest was on “illustrates angles of elevation and angles of depression” (19.6%). During the post-test, the students acquire the highest performance level on “The six trigonometric ratios” (77.5%), while the lowest performance was on “Solving problems involving oblique triangle” (46.7%).

Overall, the total mean score for the pre-test was 7.66 (25.5%), interpreted as very low mastery, and 16.87 (56.2%), construed as a low mastery for the post-test, which displayed an increase of 9.24. Results presented a difference in the students' performance in the group from pre-test to post-test. The table revealed an increase in the mean of post-test of 3.1, 1.9, 3.7, 2.3, 4.6, and 1.4 on competencies 1 to 6, respectively. It indicates that the students in the implementation group who employed the instructional materials enhanced the students' procedural fluency in terms of the lessons incorporated in the study. With the result, it is implied that the students who were taught utilising the supplemental materials obtained a high mean score in the post-test since there was an increase in the mean score of the pre-test.

The possible reason for this accomplishment and improvement in performance level may be attributed to the supplemental materials, which enable students to comprehend well and exert effort in learning. One of the students expressed her thoughts about learning with the materials which is the way she applied what she has learnt and the way to achieve the goal.

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The students explained:

Student 3: "In achieving our goal, we require to possess hardship or work through step by step, hence, it will be easy for us to perform such things".

Student 7: "I have some difficulties in finding the best way to solve the problem, particularly of which trigonometric ratios will be utilised. However, by trying to understand the problem, again and again, I can solve the problem".

Based on the student's entry, they learned to solve trigonometric ratios based on their growth mindset. Even though solving worded problems was complicated, they attempted their best to discover the right answer. The student explained that learning step by step to solve the problem was significant for her to better understand the problem and to succeed identifying solutions.

In conclusion, the lessons and activities in the supplementary material significantly enhanced the students' procedural fluency. The data collected corroborated the students' reflection, and it revealed that employing activities (such as studying with the instructional videos that allow them to think, reflect and correlate their lives to the lessons) enables the students to understand the mathematics concepts better. Moreover, the students manifested a growth mindset in mathematics, leading them to strive and learn the topics more.

Table 4 portrays that the mean scores of the students in the comparison group during the pre-test were interpreted as low mastery of "angles of elevation and depression", "Solving real-life problems involving right triangles", and "the laws of sines and cosines, and very low mastery for "the six trigonometric ratios", "trigonometric ratios of special triangles" and "solving problems involving oblique triangle". Observing the data, the learning competency "solving real-life problems involving right triangles" (46.7%) possessed the highest performance level while the lowest was on "Solving problems involving oblique triangle" (26.7%).

Based on the same table, in the post-test of the comparison group, the students acquired the highest performance level on "real-life solving problems involving right triangles" (63.3%), while the lowest performance was on "trigonometric ratios of special triangles" (37.5%). Data also unveiled that the students owned low mastery of all six competencies.

Overall, the total mean score for the pre-test was 10.67 (35.6%), construed as very low mastery, and 13.93 (46.4%), also portrayed as a low mastery for the post-test. Based on the table, it could be inferred that the utilisation of the traditional method of teaching and reference materials also enhanced the students' procedural fluency in terms of the lessons encompassed in the study, with the mean scores of 10.67 and 13.93 in the pre-test and post-test, respectively, which displayed an increase of 3.23.

The implementation group possesses a higher increase with an increase of 9.24 for the implementation group than the comparison group with an increase of 3.23. A t-test for an independent sample was administered to determine if there was a significant difference in the mean gain scores of the students between the implementation and comparison groups in procedural fluency. The results revealed a significant difference between the mean gain scores of the two groups, conveyed by the t-value of 4.890 and p-value of 0.000, which was significant at a 95% confidence level.

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Comparing the increase of the mean score of the implementation group to the comparison group, the implementation group owns a higher increment with an increase of 9.24 for the implementation group compared to the comparison group with an increase of 3.23. The study uncovered that the students in the implementation group taught by applying the supplementary materials enhanced procedural fluency in mathematics more than those in the comparison group. The latter was taught by the traditional method and did not employ supplementary materials.

Bautista (2013), in his study, revealed that to remodel students' performance on procedural fluency and mathematical explanation toward problem-solving, the instructional activities, mindset, and contents have to be complementary to one another. Furthermore, the study by Arthur, Dogbe, and Asiedo-Addo (2021) discovered that motivation in learning mathematics and quality of mathematics teaching obtained significant positive effects on students' mathematics performance.

In the present study, the improvement in the implementation group could be attributed to the student's application of the supplementary materials in which they are able to learn the materials at home. The contribution of the study in elevating the students' procedural fluency were administering the motivational activity with a growth mindset that helps the students be motivated to learn and possess a high interest in learning the topics in mathematics. Reflective learning activities provide a clear goal for attaining the learning objectives in which students are encouraged to perform reflection activities. The instructional videos help students learn and comprehend more of the concept at home and be able to employ technology such as phones and computers as an additional tool for researching instructional resources.

The study by Sharma (2018) discovered that students receiving steady experience to instructional videos and real-life activities performed better than students receiving some of the exclusive instructional treatments. The students, during the interviews, manifested their belief that instructional videos and real-life activities were able to enhance their understanding on mathematical concepts.

Effects on the Students' Mindset in Mathematics

The effects of the motivational activities on students' mindsets were also the manifestations of the development of a growth mindset among students in performing the activity. Dweck's (2006) mindset questionnaire was administered to calculate it by utilising an interview schedule. Students answered with a growth mindset or a fixed mindset for each statement. A student with a growth mindset and some fixed ideas experienced that his or her mathematical skill could be improved, but he or she also believed that some aspects of his or her mathematical skills could not be modified.

A student with a fixed mindset, on the other hand, acknowledged that his or her mathematical skills could not be changed or elevated; nevertheless, he or she might believe that it could be enhanced in certain ways. The data was analysed through frequency count after determining the students' mindsets. Table 5 presents the summary of the pre-test and post-test frequency counts of the students' mindsets in the implementation group and comparison group.

In the implementation group, 17 students owned a “fixed mindset with some growth ideas”, while 13 possessed a “growth mindset with some fixed ideas”. 13 students owned a fixed mindset with some growth ideas during the post-test, 14 students possessed a growth mindset with some fixed ideas, and three students owned a strong growth mindset.

Table 5

Summary of the Pre-test and Post-test Frequency Counts of Two Groups on Growth Mindset in Mathematics

Mindsets of the students in Mathematics	Pre-test		Post-test	
	Implementation Group	Comparison Group	Implementation Group	Comparison Group
Fixed mindset	0	0	0	0
The fixed mindset with some growth ideas	17	10	13	9
Growth mindset with some fixed ideas	13	19	14	19
Strong growth mindset	0	1	3	2
Total	30	30	30	30

While 19 students in the comparison group possessed a growth mindset with some fixed ideas, ten students owned a fixed mindset with some growth ideas, and one student possessed a strong growth mindset during the pre-test. Nine students acquired a fixed mindset with some growth ideas during the post-test, 19 students obtained a growth mindset with some fixed ideas, and two students gained a strong growth mindset.

Based on the results, the implementation and comparison groups had students in the pre-test with a “fixed mindset with some growth ideas”. The students in the implementation group all exhibited a growth mindset in the post-test, with no students possessing a robust fixed mindset. However, the post-test presented that one student was moved from the students with a “fixed mindset with some growth ideas” to the students with a “growth mindset with some fixed ideas”, and nothing was added to the students with a “growth mindset with some fixed ideas”, elevating the strong growth mindset from one (1) to two (2).

Specifically, during the post-test in the implementation group, three students from growth mindset with some fixed ideas were involved to the students with a strong growth mindset, and four students from fixed mindset with some growth ideas were joined into a growth mindset with some fixed ideas. Meanwhile, the one student in the comparison who was transferred to possess a growth mindset with fixed ideas in the post-test obtained a fixed mindset with some growth ideas in the pre-test. Furthermore, one from a growth mindset with fixed ideas was switched to strong growth mindset.

During the post-test in the implementation group, the three students who leaped to students with a strong growth mindset enhanced more than the other students. The other students have also developed their growth mindset, although just a little. Based on the findings, students in the implementation group cultivated a stronger growth mindset than students in the comparison group.

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The students in the implementation group acknowledge the significance of a growth mindset in their education. During the interview, a student (Student 21) moving from a growth mindset with some fixed ideas to a strong growth mindset stated the following:

“Nakatabang po talaga sya (motivational activities) sako kasi, sa kada lesson, ugwa pong inspiring quotes na nagmomotivate samo, pati si mga activities about motivation nakatabang sya na marealize me na kaipuhan ming mag adal para makatapos saka makagraduate” (The motivational activities tremendously assisted me a lot because in every lesson, there are quotes which encourage us to possess a growth mindset, and the activities about motivation help us realise that it is crucial for us to learn diligently to accomplish our study, to graduate).

Students’ development of a growth mindset might be associated with utilising supplemental materials, which enhances a growth mindset through self-learning that emphasises efforts in learning mathematics, in accordance with the students’ statements, as previously outlined in their learning experiences. Sun (2019) argued that current school mechanisms, such as tracking regulations, instructional methodologies, and standardised assessment, may postpone teaching which consistently initiates growth mindset messages concerning mathematics ability. It indicates that supplementary materials which utilise activities to promote a growth mindset in mathematics could help the students develop a growth mindset despite different external factors that convey fixed mindsets.

The supplementary materials were formulated to enhance students’ growth mindset in mathematics, as the motivational activities with the integration of the principles of growth mindset are able to make students more engaged in the learning process. Harackiewicz et al. (2018) emphasised that interest is a robust motivational mean which elevates learning and is essential for the educational success. When students develop their interest in studying mathematics due to the motivation, their desire to learn escalates. It implies that teachers should determine both considerations in enhancing students’ interest and growth mindset in their instruction.

Boaler (2013) explained that through instructional and classroom activities, teachers and institutions regularly transfer messages to students regarding their skill and comprehension (i.e., instructional materials). She emphasised that a thorough review of all areas of education is required if one is genuinely committed to the transfer and training of a growth mindset. She added that, norm-setting, questioning, committing mistakes, providing activities, grouping, grading, and feedbacking were all employed to convey mindset messages.

Briggs (2015) asserted that a growth mindset can alter goals and perceptions of achievement. He emphasised that conducting growth mindset-related actions such as employing the word “yet”, learning from others’ failures, setting new goals for each goal achieved, taking opportunities in the company of others, and thinking realistically about time and effort can eventually help students enhance the growth mindset.

The students were demanded to share their experiences by writing them in their journals to corroborate the study’s findings with the actual manifestations of the development of a growth mindset among the students in performing the activities. The students’ responses in the informal interviews and focus group discussions were also sources to examine the manifestations of the development of a growth mindset among the students.

After thematic analysis of the unstructured interviews responses, focus group discussion notes, and journals entries of the student during the implementation and after the utilisation of the supplemental materials, five themes were generated (Table 6): The students (1) acknowledging and embracing imperfections, (2) viewing challenges as opportunities, (3) replacing the word “failing” with the word “learning”, (4) providing regular opportunities for reflection, and (5) thinking realistically about time and effort. Sample statements of the students in each theme were presented in the matrix in Table 6.

The students’ statements imply that the students developed their growth mindset by acknowledging and embracing imperfections. The students accepted that the activities were difficult, but it manifested that they possessed a growth mindset due to their acknowledgement of imperfections. Another manifestation of the development of a growth mindset was the student’s response during the interview, which was by replacing the word “failing” with the word “learning”, and the students learned to perform their best even when they committed mistakes. It may be attributed to one of the elevated supplementary materials, reflective learning activities, which allow the students to reflect on their learning. It is a method of learning in which the students are able to reflect upon their learning encounters.

Based on the students’ reflection, they acknowledged that through the effort, he could learn to solve problems. According to Le Cunff (2022), another thing about enhancing a growth mindset is situating growth before speed. She asserted that fast learning does not necessarily mean equate to good education and learning well requires an investment of time. It means that students should also think about the importance of time and effort in acquiring new skills. Based on the student’s response, it was identified that the student understands that it takes time to grow and improve.

Table 6
Sample Statements of the Students in Each Theme

	Themes	Description
1	Acknowledge and embrace imperfections	<i>“Today, I experienced that those activities are not easy to resolve, but if we perceive all things positively, we can achieve our goals”.</i>
2	Perceive challenges as opportunities	<i>“I learned to improve myself, particularly in solving skills, by studying in this module about matrices solving real-life problems and being positive”.</i>
3	Replace the word “failing” with the word “learning”.	<i>“Today, I also learned to be positive. Even though I committed mistakes, I attempted my best to learn from them. Somehow solving involving right triangle is not easy, but I was willing to learn so that I tried”.</i>
4	Provide regular opportunities for reflection	<i>“I learned that learning could be everywhere. We could learn everything at any time from anyone or ourselves. I learned that to learn. We required the effort to accomplish something. Today, I learned that learning is the best way to progress. We required to perform whatever we could do; we just needed to put some effort to do good and solve problems even in real-life experiences”.</i>

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	Themes	Description
		<i>“Learning fast does not mean learning well, and learning well requires allowing time for mistakes. Thinking realistically about the time and effort is required to acquire a new skill”.</i>
5	Think realistically about time and effort	<i>“In our life, success is the very best thing to acquire but in order to succeed, you need to set your goals, put more efforts, learn from mistakes, try our best to solve the challenges we have, like in solving trigonometric, we need to effort to solve and identify the solution to attain the correct answers and try our best to determine the right value of it”.</i>

Overall, the students’ mindsets shifting from a fixed mindset to a growth mindset is one of the impacts of utilising the developed supplementary materials such as motivational activities, reflection activities, or instructional videos. The study results are associated with the study of Masterson and Koch (2021). The research result discovered that moving from a fixed mindset to a growth mindset required adjustments to the mathematics methods. In this study, supplementary materials integrating growth mindset principles are able to help students develop a growth mindset in mathematics.

Conclusion

The supplementary materials developed to integrate growth mindset principles were motivational activities, reflection activities, and instructional videos. The students possessed significant learning experiences by employing supplementary material, which developed procedural fluency and assisted students in shifting from fixed mindsets to growth mindsets in mathematics. The students learned to acknowledge and embrace imperfections, view challenges as opportunities, acknowledge failures as a key to learning, reflect on learning, and think realistically about time and effort. The implementation of the supplementary materials affects students’ procedural fluency and mindset in mathematics better than conventional teaching in accordance with the findings of this study. In strengthening students’ learning and growth mindset, researchers could employ the supplementary materials in various areas of learning and with larger sample sizes.

Acknowledgement

The students, parents, educators, and school principal who participated in the study were acknowledged for their participation and cooperation during the implementation and data collection. The researchers also appreciate the Department of Science and Technology for providing funding and the Department of Education for approving the study in the school.

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*Enhancing Mathematics Learning by Integrating Growth Mindset Principles
in Ninth-Grade Supplementary Materials*

RESEARCH ARTICLE 12

Global Teaching Approaches in Mathematics: Addressing Learning Domains for Holistic Student Development

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Participatory Educational Research, 12(5), 67–88

Original publication: 2025



Participatory Educational Research (PER)
Vol.12(5), pp. 67-88, September 2025
Available online at <http://www.perjournal.com>
ISSN: 2148-6123
<http://dx.doi.org/10.17275/per.25.64.12.5>

Id: 1634338

Global Teaching Approaches in Mathematics: Addressing Learning Domains for Holistic Student Development

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Article history

Received:

06.01.2025

Received in revised form:

25.05.2025

Accepted:

02.07.2025

Key words:

Cognitive, Affective,
Psychomotor, Learning
Domains, Teaching
Approaches

To promote student learning in mathematics education, the three learning domains, namely the cognitive, affective, and psychomotor domains, must be addressed to encourage overall development and prepare students for life's challenges. This paper is a literature review of diverse studies and practices across the globe on raising student achievement, considering the three learning domains employing a systematic literature review and following the PRISMA approach, the Preferred Reporting Item for Systematic Reviews, and Meta-Analyses. Of the 200 identified research studies, 33 qualified and were included in the analyses. Findings showed that technology-based learning is the most appropriate teaching strategy for developing cognitive and psychomotor skills when learning mathematical concepts. It provides virtual and controlled settings that foster knowledge assimilation and application. In the affective learning domain, inquiry-based, representation learning, and culturally responsive learning are most effective as they increase students' involvement, learning participation, and thinking through collaborative and blended learning environments. The study recommends integrating blended learning, multiple representations, and meaningful assessments to enhance students' cognitive and problem-solving skills. Culturally responsive teaching, digital tools, and experiential learning activities to improve students' engagement, motivation, and practical application. The study recommends further research on these approaches to validate their effect on students' holistic development in mathematics education.

Introduction

Learning demands and the current level of development are already changing through the new generation objects of globalization learning environments (Zhao et al., 2023). Thus, mathematics is an academic discipline that enhances cognition and evaluates competencies required in academic and working life and individual or collective development (Niss, 2018).

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Nevertheless, teaching practice in mathematics education exposes students and educators to the struggle to meet the emerging demands of globalization, technology inclusiveness, and a student-centered approach (Yusri et al., 2024). Such challenges call for creativity in course delivery approaches that address all learning domains, such as cognition, affect, and psychomotor domains, instrumental in shaping student character (Henriksen et al., 2021).

The cognitive domain, which is concerned with acquiring knowledge, intellectual skills, and thinking skills, is the primary domain for mathematics education. It insists on the conception and application of ideas, the analysis of problems, and the synthesis of information. Thus, it is pivotal in mathematical competence. The affective aspect deals with people's willingness and interest in numbers to avoid math phobia (Luo, 2024). At the same time, the Psychomotor domain, which is associated with physical experiences and learning implementation in terms of tangible objects and actions, provides practical problem-solving of mathematics and procedural knowledge in this area. Collectively, these domains form a coherent model of practice for teaching mathematics with learning and instruction at its center.

The approach to teaching in an era of globalization has shown possibilities in the transformation of the learning of mathematics to meet these domains comprehensively (Yusri et al., 2024). Inquiry-based learning, Project-based learning (PBL), and Blended learning are the teaching approaches that align with the cognitive domain. They ensure intellectual components without compromising the affectivity and motor aspect with intricately designed and almost real-life illustrations (Beckett et al., 2020). Education tools and applications complement this process by developing engaging educational experiences that require users to engage with content proactively and be active players (Henriksen et al., 2021).

Nevertheless, the integration of these domains in a holistic manner is still a research question in mathematics education (Ali, 2024). Research has shown that while students can cope cognitively with learning outcomes, there is a lack of a more sensitive approach to addressing their emotional and physical techniques as they solve problems or engage in computational tasks (Luo, 2024). This lack of appreciation hinders educational practices from equipping students with the complex skills required in the twenty-first-century education and work environment, thus calling for integrated curricular teaching and learning approaches that foster soft skills, hard skills, and technological knowledge use.

With this, Project-based learning (PBL) as an instructional framework combines various learning domains through student inquiry and solving practical problems (Garib, 2022). The educational community has extensively studied PBL application in STEM and engineering but lacks research on its effects on affective engagement and psychomotor skills in mathematics (Paleenud et al., 2024). Technology integrating PBL produces interactive learning spaces that activate student thinking patterns, enhance task attachment, and enable practical knowledge implementation (Beckett, 2020).

More in tune with modern technology, digital tools, and other online collaboration platforms also continue to broaden the prospects for incorporating the three domains in mathematics learning (Dooley et al., 2016). Varieties of tools like interactive simulations, games, learning platforms, and even interactive, collaborative virtual environments promote rationality, motivation, and psychomotor activity, respectively (Henriksen et al., 2021). Nevertheless, the issues of equity, teacher preparedness, and curriculum integration should be met by the teachers if the interventions are to have the best impact (Prasetyo et al., 2023).



This study investigated the global mathematics classroom teaching approaches through a systematic literature review of the diverse studies and practices across the globe that identify the strengths and weaknesses of the approaches in raising student achievement, considering the three learning domains – cognitive, affective, and psychomotor. Further, the present study explored barriers and possibilities when teachers apply these instructional approaches within mathematics education classrooms. Specifically, it answered the following questions:

- (1) What teaching and learning approaches are used globally in mathematics education to address the cognitive, affective, and psychomotor domains of learning?
- (2) Based on research findings, which teaching approaches are most effective in improving students' cognitive, affective, and psychomotor skills in mathematics?
- (3) What challenges and opportunities arise when implementing teaching approaches that target the domains in mathematics education?

Literature Review

Students commonly use visual representations during mathematical problem-solving while maintaining essential connections between symbols and conceptual objects, schemes, and prototypical examples. Using representations in learning yields both internal and external effects on students. Previous knowledge, personal preferences, and mathematical beliefs form internal effects that impact students through rote learning and personal experiences. In contrast, external effects derive from problem presentations and sequential mathematics curricula (Mainali, 2021). According to Buscher et al. (2022), teachers sometimes adjusted their instruction approach either by simplifying mathematical tasks or switching between different mathematical activities because they believed different classroom requirements conflicted

Other teaching approaches that improve cognitive skills are the AI implementations in education systems currently creating revolutionary changes to teaching approach as shown in Díaz (2024). Teachers using virtual reality technology develop immersive experiences for students whose situations match the style of learning content (Zhan, 2024). Digital learning resources support teacher instructional goals and education diversity in classrooms. Teachers' didactic purposes when using DLR need additional study in classroom applications (Villasmil, 2024). Good teaching practices continued to develop through teachers recognizing mobile devices as suitable learning tools and their conviction about mobile learning's emerging popularity throughout the next few years. The analysis demonstrated why educators must demonstrate favorable attitudes toward mobile learning (Aznar-Díaz et al., 2020).

Implementing digital learning technology in universities offers exceptional possibilities for designing adequate cognitive learning spaces that can benefit present-day and future emergencies. The flexibility of online learning environments that provide both temporal and spatial/geographical flexibility allows numerous students with diverse constraints, such as parenthood alongside the remote location of residence or part-time enrollment, to access potentially high-quality university instruction (Hofer et al., 2021). A team of volunteer lecturers operates Math education through joint efforts, which produce platform content by creating and reviewing educational materials and questions. The platform offers questions that students need to interact with for improved knowledge acquisition (Flamia et al., 2024). The Problem-based learning concept demonstrated success, which makes it suitable for Ghanaian teacher education programs where it serves as an instructional strategy for transferring mathematical knowledge and skills and facilitating accurate generalizations. Pre-service



teachers developed student-centered approaches because PBL combined interactive teaching with facilitator-student interaction, enabling students to cooperate to achieve goals through group teamwork and improved student-to-student communication (Boye et al., 2023).

Through online teaching, students gain fundamental roles in developing their academic content. Students gain active participation through the system when needed while benefiting from a wide range of available study resources. The online assessment, as described in the articles, educates students while challenging them to show comprehension through different virtual platforms, simultaneously improving their digital proficiency and virtual presentation and communication abilities (Casadesús et al., 2024).

It is difficult for lecturers to attempt assessment practice modifications and implement multiple approaches stipulated by modern learning assessment without receiving feedback from students and decision-making stakeholders (Mardiana et al., 2020). The teacher requires extensive knowledge of mathematics and awareness of contemporary but traditional mathematical applications and must grasp the psychological factors and child development aspects of children in our current technological era. Additionally, they should comprehend present student inclinations in interpersonal communication. Teacher workload was a major influence as they taught Mathematics across different (by age) classes throughout one academic year (Tarasenkova et al., 2020).

The teachers must distinguish active learning practice from adding more content into tight lesson periods. Mathematics Teacher Educators make judicious choices for instructional tasks, facilitating students' ability to reason and solve problems. Students' content knowledge growth occurs when Mathematics teacher educators model instructional approaches that future teachers will need while teaching them how to create valid mathematical arguments along with a group discourse approach. MTEs prepare pre-service teachers to fulfill mathematics classroom expectations (Litster et al., 2020) by providing dynamic learning activities for maths content subjects combined with explicit discussions of their benefits for both personal comprehension and their future students' math learning achievement.

Traditional games and livelihood activities demonstrated the mathematical concepts in traditional practices. Traditional games and livelihood activities validate that mathematics is an essential cultural phenomenon. The students acquired novel mathematical understanding through culturally relevant instructions, increasing their numerical interest (Samaupan, 2019).

The educational approach that employs realistic mathematics principles in smart mobile teaching devices fundamentally influences children between 4 and 6 years old for multiplication learning outcomes. Students learn multiplication more effectively by implementing smart mobile devices than traditional approaches. Traditional teaching techniques have minimal influence on multiplication reproduction in 4-to 6-year-olds. (Fotini, 2019). Students gain valuable understanding through their experience of learning with internet technology. With the Internet, students can learn anytime and anywhere without physical contact with their instructors. Utilizing Moodle as a learning platform improves students' academic results (Handayanto, 2018). The educational approach to mathematics learning through Realistic Mathematics Education alongside blended learning produces substantial differences compared to classic instructional techniques. The study outcomes of mathematics lessons demonstrated substantial growth in the students following the blended learning-based RME model beyond the findings in classes adopting a conventional educational approach (Sari et al., 2020).



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Technical capabilities hold importance, but students have less digital competency than teachers anticipate, so informational aspects and social factors prove to be essential. Effective teaching with Technology occurs through collaborations between instructors and students to develop student-driven practices that are differentiated and situation-based for shared education. Understanding Big Data teaches students and teachers to recognize BD operational principles and the data they wish to present through BD systems. Integrating BD into education enhances educational management systems and enables people to gain deeper self-knowledge and develop their skills effectively. BD helps researchers investigate Malaysia's educational sector in greater depth, according to Jia et al. (2022).

The assessment of student achievement needs to change because students must have new abilities and knowledge that can be adapted to the global economic era of the 21st century. In this era, students not only need a basic understanding but also need to think critically, analyze, and make decisions. Helping students develop these skills will make a difference and represent a new assessment approach (Mardiana et al., 2020).

The PBL Realistic Model principles allow student-teachers to carry out learning activities effectively, according to Rivdya et al. (2018). Chemlal et al. (2023) proposed incorporating sustainable education into educational teaching and learning procedures. On the other hand, implementing audiovisual technology assistance enables teachers to share vast content with students while demanding minimal work to deliver in less time. Audiovisual Technology provides assistance that helps students cope with mathematics learning obstacles while making the lesson both captivating and effective for primary school students in grades 7-9 during their didactic lectures. Research outcomes could benefit from a distinct examination of audio versus video components, which would provide additional details on TA effectiveness, and teachers can implement multiple student evaluation approaches and explore teaching Mathematics with devices including smart boards and iPads, etc. (Alshatri et al., 2019).

Method

Research Design

The study utilized a systematic literature review (SLR) approach. Through SLR, researchers acquire pertinent research studies (such as articles, conference proceedings, books, and dissertations) by implementing a systematic approach (Carrera-Rivera, 2022). The SLR approach combines scientific evidence regarding specific research questions by presenting all published evidence for the study and examining evidence quality openly and repeatedly (Lame, 2019). The study adopts Kitchenham's (2004) three-stage systematic literature review framework with elaborations by Xiao and Watson (2019). The stages include planning, review process, and report preparation, all with images to elaborate on the explanations.

Application Process and Data Analysis

As shown in Figure 1, the planning includes the development of a working parameters formula for the operational standards, articles to be included or excluded, and the identification of the review process to be done (Zakariya, 2022; Tagscherer & Carbon, 2023). The planning stage requires the formulation of operational standards (Zakariya, 2022), specifications for articles, the specification of inclusion/exclusion criteria, and the definition of the review process to be undertaken (Tagscherer & Carbon, 2023).





Figure 1. Procedure Review Process

The review stage encompasses three key activities: defining data sources, data abstraction, and data analysis, with full compliance with operational norms. Meanwhile, the last stage, reporting, involves expressing an opinion through conclusions and recommendations supported by implications and research limitations.

Data Source & Abstraction

In this study, the researchers conducted the article selection process with the help of the Publish or Perish application, with special consideration given to the articles listed in the Scopus database. Databases have a significant role in this process since they contain the publication metadata and bibliometric measures for the validity and accuracy of the results (Yusri et al., 2024).

Initially, the articles were retrieved by entering a list of carefully selected phrases such as Teaching Approaches, Cognitive, Affective, and Psychomotor. These keywords focus on articles published in a specific 2018-2024 timeframe to include recent work relevant to this field.

Table 1 Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Types of Research	Quantitative, Qualitative, Development, Mix Approach	Review
Language	English	Other than English
Article type	Research article	Books, chapter books, and proceedings
Year of Publication	2018-2024	2017-below

By searching through the Scopus database available through publish or perish, articles were searched using the keywords and yielded 200 articles. After this, the articles were further



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subjected to an eligibility assessment based on the inclusion and exclusion criteria, as shown in Table 1. This step is instrumental in excluding many irrelevant or low-quality research proposals in the final examination and remaining relevant to the set research objectives. After the screening, 33 research articles qualify for the review.

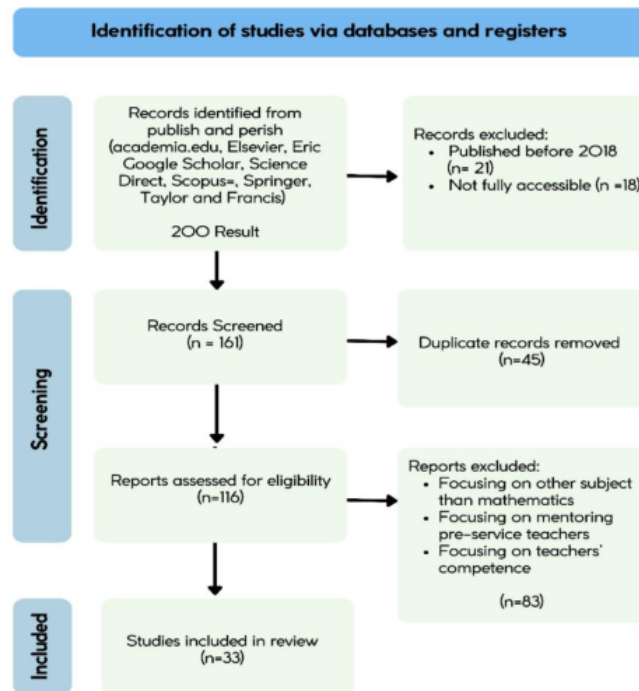


Figure1.PRISMA Flow Diagram 2020 of Literature Research and Review Process

There are specific directions concerning the conduct and reporting of literature searches in the systematic review processes, which are important for making the processes transparent and rigorous. This study followed the PRISMA approach, the preferred reporting Item for systematic reviews and meta-analyses. The main aim of PRISMA is to help systematic reviewers report transparently the reason for the review, the conducted review approach, and the obtained important findings. This study follows the four key phases outlined in PRISMA: The key themes include identification, screening, eligibility, and inclusion (Page et al., 2021). Such phases are employed systematically to attend to specific queries focusing on the studies for choice, from the preliminary search to the ultimate selection. As mentioned above this provides structure to the process while guaranteeing that the review approach fits the research objectives.

Research Data Analysis

The essential part of the review process of this study is the peer-reviewed analysis of the articles sourced after identifying data sources and abstracting systemic literature review data. The review process used the structured review protocol encompassing four key components: bibliography, research details, focus, and publication content. Identified article

features include author and year of publication, article, type of publication, journal or source name, title, and scope of the study. These details create a basis for understanding the context of each important article for the research topic.

The findings section further explores the approach used in the research. It focuses on the studies' objectives, research approach, sample, population, and models/frameworks. This aspect facilitates a structure-based comparison of approaches in the literature, which aids in identifying similarities and, possibly more importantly, disparities. The focus stage guarantees that the selected articles are relevant to the research questions provided in the introduction part and reflects the extent to which the investigations meet essential areas of concern. Finally, the publication's content entails an analysis of findings, specifically the kind of media and technological tools employed, the efficacy and impact of these interventions, and explorations of approach logical or contextual moderators. This approach ensures that the review is comprehensive, organized, and directly aligned with the study's objectives, facilitating meaningful insights and contributions to the field.

Bibliographic Analysis

This study analyzed global approaches addressing cognitive, affective, and psychomotor domains. Articles included were published in the years 2018 to 2024 to ensure an overview of the most up-to-date trends, research approaches, crucial components, necessary abilities, and frameworks researchers use to determine teaching approaches addressing students' cognitive, affective, and psychomotor domains. Bibliographic analysis will show the general information of the article. Below is an example of a reference table for bibliographic analysis in one of the articles.

Table 2 highlights the bibliographic information of the 33 articles included in the study. The primary source of the articles is Academia. Edu with 19 (57.57%) of the articles included. Second on the list is Scopus with 9 (18.18%), followed by Science Direct with 2 (6.06%). At the same time, the last source is Eric with 1 (3.03%) amongst the 33 articles.

Table 2 *Essentials of Bibliographic Information*

Information	Characteristic	Frequency	Percentage
Source	Academia	19	57.57
	Eric	1	3.03
	Science Direct	2	6.06
	Scopus	6	18.18
	Springer	2	6.06
	Taylor and Francis	3	9.09
Total		33	100.00
Area	Asia	13	39.39
	America	5	15.15
	Europe	10	30.30
	Australia	1	3.03
	Africa	4	12.12
Total		33	100.00
Education Level	Higher Education	16	48.48
	Secondary	9	27.27
	Elementary	8	24.24
Total		33	100.00



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Furthermore, other information in the illustration above is the division of articles according to the research area. Asia dominates with 13 (39.39%), followed by Europe with 10 (30.30%) articles. Next on the list is America with 5 (15.15%), Africa with 4 (12.12%), and lastly Australia with 1 (3.03%) from the 33 articles. Regarding educational level, 16 (48.48%) of the articles are conducted at higher education, while 9 (27.27%) are from the secondary level. Lastly, 8 (24.24%) are conducted at the elementary level. The following is a graphic illustration of the distribution of articles in years of publication.

Based on the illustration in Figure 3, the year with the most publications was 2020, with nine (27.27%), followed by 2019, 2022, and 2024 with five (15.15%). In addition, four (12.12%) of the articles were published in the year 2021, three (9.09%) were published in 2018, and lastly, two (6.06%) of 33 articles were published in the year 2023.

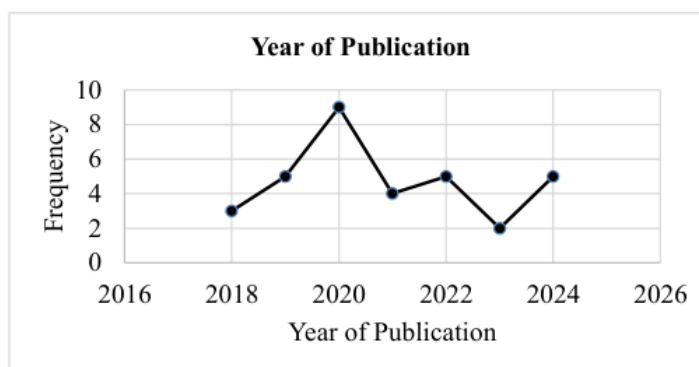


Figure 3. Distribution of article publication years

Analysis of Research Details

The breakdown of the research details aims to examine the approach used in the articles that formed part of this research. Only empirical articles or those containing research data could be accepted. By using this criterion, the review avoids getting sidetracked by irrelevant information while at the same time guaranteeing that only credible research based on data has an impact on the achievement of the study's aims and objectives. The following is an example of an analysis of an article that contains detailed research information:

Table 3 *Example of detailed research information*

Researcher's Name	Luhuan Huang et al.
Article Title	Inquiry-Based Learning Practices in Lower-Secondary Mathematics Education Reported by Students from China and the Netherlands
Research Details	The aim of the study is to better understand Inquiry-based learning practices in connection with overarching teaching cultures.
Research Approach	Quantitative-Descriptive Approach
Sample and Population	867 Students
Research Place	Freudenthal Institute, Utrecht University, Netherlands

Table 3 shows the detailed research information, including research objectives, approach, sample and population, and location. Of these, the most significant aspect is the research approach that has critically impacted this research because the systematic literature review

(SLR) does not allow any secondary literature, and conducting a literature review comprises primary research articles. For this reason, the study assessed current research collections based on percentage distribution to establish the proportion of research works that fit into the SLR category.

Analysis of Article Focus and Content

This section analyzed the entire content of the results and the discussion in the article. To obtain information that will answer the research questions. The following is an example of information obtained from one of the articles.

The information collected through this table focuses on four main things: the teaching approach, the domain on which it had an impact, the efficacy of the teaching approach, and challenges and opportunities during implementation.

Table 4 *Sample of Focus Information and Content Discussion*

Researcher's Name	Luhuan Huang et al. (2021a)
Article Title	Inquiry-Based Learning Practices in Lower-Secondary Mathematics Education Reported by Students from China and the Netherlands
Teaching Approach	Inquiry-Based Learning
Domain	Affective
Effectiveness	The study suggests a correlation between Inquiry-Based Learning experience and Inquiry-Based Learning preference of each class
Challenges and Opportunities during Implementation	Limitation of reporting IBL practices solely from a teachers' perspective.

Results and Discussion

Teaching and Learning Approaches Used Globally in Mathematics Education to Address the Domains of Learning

After conducting an in-depth review of 33 articles, seven (7) teaching approaches are identified, namely, Representation learning with one (3.03) among the studies, Problem-Based Learning, and Remote learning with two (6.06%), Assessment-Based and Cross-Cultural-Based Learning with three (9.09%). Furthermore, ten (30.30%) articles used Technology-Based learning, while twelve (36.36%) used Inquiry-Based learning.

Inquiry-based learning was the most used teaching approach among the 33 articles included in the study. According to the reviewed literature, it is evident that the use of multiple teaching approaches enhances mathematical learning in the cognitive, affective, and psychomotor domains. Educational technology integration for system-based learning enhances the process by creating real-life and innovative models.



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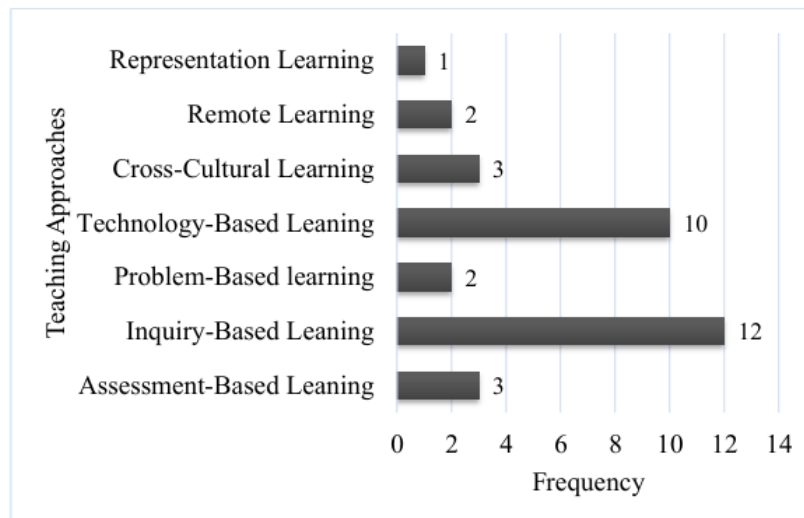


Figure 5. Teaching and learning approaches globally used in mathematics education

For instance, Zhan (2024), the author pointed out that virtual reality offers an opportunity to produce suitable and interesting contexts to present mathematical materials. In turn, Fotini (2019) provided evidence on how smart mobile devices enhance young students' multiplication accuracy. Similarly, Azevedo et al. (2024), as well as Viberg et al. (2020), also mentioned that the use of mobile and app-based learning brought out benefits such as structuring of activities, which can be used to influence and direct the students in their learning process. Altogether, these research works and proposals coalesce to the achievement that points out the transformative role of technology in mathematics learning.

A curiosity-driven approach also turned out to be an effective practice concerning which students' critical and analytical skills improved significantly. In their study conducted in 2020, Sari et al. also stated that students' learning outcomes in the subject increased, based on the blended learning models that follow the principles of inquiry, significantly higher than the traditional learning models based on the N-gain score. In addition, Handayanto (2018) suggested the features of Moodle-based platforms for improving student engagement. In addition, Litster et al. (2020) underlined that inquiry-based learning experiences can improve pre-service teachers' mathematical knowledge and affect future teaching practices. These results support the increased understanding of directed and purposeful learning experiences.

Representation-based teaching approaches, as illustrated in Mainali (2021) and Ali (2020), allow students to map reality into their math knowledge. Mainali (2021) highlighted students' appreciation of using tools such as models and symbols in problem-solving mathematics. In the same way, Ali (2020) illustrated that tools such as the Realistic Mathematics Education (RME) model increase students' problem-solving skills when structures are related to phenomena. Such approaches emphasize the reality that people learn better when ideas are endowed with familiar settings so that they can get a better understanding of the material.

Cross-cultural and culturally relevant teaching approaches serve as an additional dimension of strength in teaching mathematics. For instance, Samaupan (2019) noted that the incorporation of cultural practices of weaving and carpentry into the lessons that teach mathematics makes

it easier for students to understand in connection with the notion of Kurniasih et al. (2021), who encouraged the use of cultural competence content in learning mathematics for the morality and identity of the nation. That way, learning is more effective since students relate their culture to what is being taught in mathematics.

Furthermore, according to Casadesús et al. (2024), students benefit from Remote Learning because it encourages active participation through improved engagement and more dynamic learning opportunities. Extended resources combine digital assessments to develop student digital competencies, virtual communication skills, and practical visual information presentation abilities.

Problem-based learning (PBL), according to Boye et. Al (2023) is an effective teaching approach in Ghana. PBL strengthens student-centered practices, encourages teamwork within small groups, enhances communication skills, and promotes collaboration to meet educational objectives.

According to the reviewed research, diverse teaching approaches demonstrate the substantial potential to transform mathematics education while advancing student learning across cognitive, affective, and psychomotor domains. The study finds Inquiry-Based Learning to be the predominant approach that substantially improves students' analytical capabilities alongside their mathematics competency and the pre-service instructors' mastery of mathematical principles. Educational technology tools, including virtual reality, mobile applications, and Moodle platforms, create interactive learning conditions that boost student participation while improving mathematical problem-solving abilities. Mathematical instruction through representation-based approaches combined with a culturally relevant teaching approach targets the essential connection between mathematical concepts, realistic contexts, and cultural patterns to enhance knowledge absorption. Problem-Based Learning and Remote Learning deliver student-centered learning while building digital competencies. Educational approaches demonstrate the need for multiple approaches to support varied student learning requirements and achieve better teaching and learning outcomes.

Teaching Approaches for Enhancing Students' Cognitive, Affective, and Psychomotor Skills in Mathematics

Cognitive

Table 5 *Teaching Approaches affecting the Cognitive Domain*

Teaching Approaches	Frequency	Percentage	Rank
Technology-Based Learning	8	44.44	1
Inquiry-Based Learning	5	27.78	2
Remote Learning	2	5.56	4
Cross-Cultural Learning	1	5.56	4
Assessment-Based Learning	1	11.11	3
Representation Learning	1	5.56	4
Total	18	100	

After reviewing the different teaching approaches used globally to enhance mathematic learning in terms of the cognitive domain, Technology-based learning with eight (44.44%) is more efficient. Fotini (2019) concluded that teaching using smart mobile devices significantly



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affects children from 4 to 6 years old when learning multiplication. The students who learned multiplication using educational smart devices demonstrated superior outcomes compared to children who used traditional classroom instruction.

Research by Zhan (2024) confirmed that virtual reality (VR) technology creates suitable learning environments that mirror educational content features. DLR functions as a fundamental part of teachers' didactic purposes and meaningfully diverse teaching practice while enabling students to perceive knowledge learned, according to Villasmil (2024). The findings of Aznar-Díaz et al. (2020) study demonstrated that mobile learning received a positive reception from the study participants. Student knowledge improvement results from active participation in the questions presented through the Math education platform, according to Azevedo et al. (2024). According to Niño (2019), mobile devices enable the formation of learning communities in all subjects, with a special emphasis on mathematics. The effectiveness of teamwork in problem-solving education becomes evident based on critical constructs in problem resolution.

Affective

Table 6 *Teaching Approaches affecting the Affective Domain*

Teaching Approaches	Frequency	Percentage	Rank
Inquiry-Based Learning	5	55.56	1
Cross-Cultural Learning	2	22.22	2
Assessment-Based Learning	1	11.11	3
Technology-Based Learning	1	11.11	3
Total	9	100	

Regarding teaching approaches addressing the affective domain of learning, Inquiry-Based learning with five (55.56%) is more efficient. An article by Sari et al. (2020) discovered that blended learning produced better results in mathematics study than regular classroom instruction. The experiment class had a 60.95 percent N-gain score, while the control class scored 25.67 percent. Student learning activity participation improves when students learn with Moodle, according to Handayanto's (2018) findings. Combining tasks and forum discussions through student activities enhances students' interest levels in education. Student success improves through a learning approach based on the Moodle platform. Litster et al. (2020) revealed that MTEs serve students as a vital starting point to fulfill mathematical instruction requirements by providing meaningful active learning in mathematics content sections that help both pre-service teachers and their future pupils improve their understanding of mathematics.

Psychomotor

Table 7 *Teaching Approaches Affecting the Psychomotor Domain*

Teaching Approaches	Frequency	Percentage	Rank
Inquiry-Based Learning	2	33.33	1
Technology-Based Learning	2	33.33	1
Assessment-Based Learning	1	16.67	2
Problem-Based Learning	1	16.67	2
Total	6	100	

Regarding teaching approaches affecting the psychomotor domain of learning, Technology-Based learning with 2 (33.33%) is more efficient. Though inquiry-based and technology-based learning were used in the same quantity, findings suggest that technology-based learning fits this domain's enhancement more. Jia et al. (2022) concluded that big data in education improves educational administration while enabling people to acquire extensive self-knowledge, which leads to ability enhancement. Students with positive attitudes toward the app-in-use program detected its clear structural organization and detailed explanations and solution clues, which supported continuous learning guidance.

Challenges and Opportunities in Implementing Teaching Approaches Targeting Cognitive, Affective, and Psychomotor Domains in Mathematics Education

Table 8 shows the challenges and opportunities in implementing teaching approaches targeting the domains in mathematics education.

Cognitive

As shown in table 8, some challenges have affected the success of various teaching approaches, focusing on cognitive teaching and learning dynamics in the classroom. Lack of proper exposure to an effective representation approach affects student knowledge, leading to a poor understanding of such concepts (Dolma & Thinley, 2022). Also, using tools and techniques in different learning settings leads to the inconsistency and fragmentation of knowledge management (Ali, 2020). These complexities are negated by accessibility issues such as weak ICT and the internet, particularly in distant or deprived contexts (Handayanto, 2018). On the other hand, teachers reported difficulties managing the attention and participation of students within remote settings due to reduced contact with the human body (Sari et al., 2020). In using both formative and assessment solutions, there are challenges in giving and receiving feedback and evaluations (Litster et al., 2020).

Table 8 *Challenges and Opportunities in Implementing Teaching Approaches Targeting the Cognitive, Affective, and Psychomotor Skills*

Domains		
Cognitive	- Limited exposure to effective representation methods leads to poor conceptual understanding (Dolma & Thinley, 2022). - Inconsistencies in knowledge management due to varied tools and techniques (Ali, 2020). - Accessibility issues, such as weak ICT infrastructure and internet connectivity (Handayanto, 2018). - Difficulties in managing student engagement in remote learning (Sari et al., 2020). - Challenges in providing timely and effective feedback (Litster et al., 2020). - Lack of teacher training for technology-enhanced instruction (Handayanto, 2018; Sari et al., 2020). - Cultural disconnect in mathematical learning (Kurniasih et al., 2021; Samaupan, 2019).	- Enhanced problem-solving and reasoning through multiple representations and meaningful assessments (Dolma et al., 2022; Litster et al., 2020). - Technology-enabled tools improve digital literacy, communication, and accessibility (Handayanto, 2018; Casadesús et al., 2024). - Culturally relevant teaching strategies promote engagement and understanding (Samaupan, 2019; Kurniasih et al., 2021; Huang et al., 2021a). - Blended learning and adaptive models enhance motivation and learning outcomes (Fotini, 2019; Litster et al., 2020).



	- Inquiry-based learning may not align with all cultural and educational backgrounds (Huang et al., 2021a). - Designing meaningful exploratory tasks requires significant effort (Dolma & Thinley, 2022).	
Affective	- Difficulty in fostering emotional connections with learning materials (Dolma & Thinley, 2022; Ali, 2020). - Technological barriers affecting remote and hybrid learning engagement (Handayanto, 2018). - Challenges in managing student participation and providing constructive feedback in digital environments (Sari et al., 2020). - Low cultural awareness among students reduces engagement with culturally relevant mathematics (Kurniasih et al., 2021; Samaupan, 2019). - Some students prefer traditional teaching over exploratory learning, limiting participation (Huang et al., 2021a). - Teachers lack training and resources for technology-integrated lesson plans (Dolma & Thinley, 2022; Sari et al., 2020).	- Cultural symbols and real-world applications help students construct meaningful knowledge (Ali, 2020; Dolma & Thinley, 2022). - Digital literacy skills enhance students' preparedness for online learning and employment (Casadesús et al., 2024). - Culturally appropriate activities improve student engagement and ethical sensitivity (Samaupan, 2019; Kurniasih et al., 2021). - Blended learning approaches offer flexibility, efficiency, and multiple engagement opportunities (Fotini, 2019; Sari et al., 2020).
Psychomotor	- Lack of exposure to hands-on learning affects technical skill development (Rivdya et al., 2018). - Digital literacy disparities create learning inequalities (Jia et al., 2022; Alshatri et al., 2019). - Limited physical interaction hinders practical skill growth (Jia et al., 2022). - Challenges in selecting culturally relevant and inquiry-based hands-on activities (Chemlal et al., 2023). - Traditional assessments do not adequately measure problem-solving and decision-making skills (Mardiana et al., 2020). - Difficulty in evaluating practical competencies within digital learning environments (Mardiana et al., 2020).	- Hands-on and task-based learning enhances problem-solving and motor skill development (Rivdya et al., 2018). - Virtual environments foster digital literacy and collaborative problem-solving (Jia et al., 2022). - Innovative assessments align with modern educational demands (Mardiana et al., 2020). - Culturally relevant tasks promote inclusivity and engagement (Chemlal et al., 2023). - Audiovisual tools and interactive technologies provide immersive learning experiences (Alshatri et al., 2019).

However, teachers do not always receive the proper training or support necessary to integrate such tools in enhancing instruction in technology-enhanced or blended teaching and learning contexts (Handayanto, 2018; Sari et al., 2020). Cultural responsiveness remains another imperative concern in teaching since students may not relate to what they hear or learn because cultural facts are not incorporated into learning mathematics (Kurniasih et al., 2021; Samaupan, 2019). Inquiry-based learning, which promotes the discovery and reasoning process, does not suit some cultures and educational backgrounds students' expectations and experiences, thus reducing its benefit (Huang et al., 2021a). Finally, the creation of



meaningful exploratory tasks that facilitate cognitive activity mostly remains only a great idea because they are challenging to come up with and require much effort and imagination (Dolma & Thinley, 2022).

Meanwhile, the several instructions that affect the cognitive domain also provide several advantages that facilitate improvement of the cognitive area by creating a higher level of learning, meaning-making, and cognition in the students. By associating symbols, signs, and other cultural instruments with the mathematical concepts from which the child is learning, this approach assist the child in gaining a deeper understanding of the contents to be learned (Ali, 2020). This is because they support problem-solving and reasoning through multiple representations and meaningful assessment tasks and thus enable students to reason independently (Dolma et al., 2022; Litster et al., 2020). The portability of resources also enhances learning accessibility so that students can learn from anywhere at any time. Moreover, technological tools and blended learning environments improve students' digital literacies, communication, and participation (Handayanto, 2018; Casadesús et al., 2024; Sari et al., 2020).

Learning approaches that include culturally appropriate games, crafts, and context learning increase understanding of cultural practices and morality since the lessons are created to fit the cultural practices of the students (Samaupan, 2019; Kurniasih et al., 2021; Huang et al., 2021a). In addition, technology-integrated ways and adaptive blended learning models enhance learning outcomes and motivation and solve collaborative problems and real-world issues best (Fotini, 2019; Litster et al., 2020). All these approaches contribute to forming a warm and friendly learning atmosphere, which addresses the challenges facing modern learning.

Affective

On challenges that teaching approaches related to the affective domain experience challenges in student involvement, cultural understanding, and development of feelings. Inadequate or infrequently used practical representational tools pose difficulties for students developing emotional connections with materials or tasks (Dolma & Thinley, 2022; Ali, 2020). Technological disadvantages such as internet connection also worsen remote or hybrid learning processes (Handayanto, 2018). Teachers remain challenged in managing student participation and the likelihood of formative and assessment feedback using informative and constructive feedback in implementing digital technology into the classroom (Sari et al., 2020).

Furthermore, the students of this generation may not be very aware of their cultural background, which reduces the focus to culturally related aspects of mathematics (Kurniasih et al., 2021; Samaupan, 2019). The low incorporation of cultural significance and the inclination of certain students to conventional ways of learning rather than discovering lessen effective participation (Huang et al., 2021b). Similar emotional appeals are a challenge for teachers in the creation of open-ended tasks, which are often not provided with the training or resources necessary to integrate digital technologies within lesson plans or transition to technology-integrated curriculums (Dolma & Thinley, 2022; Sari et al., 2020). These challenges call for culturally sensitive, resource-embedded, and emotionally appealing approaches to improving the quality of effective learning.

Meanwhile, teaching approaches aimed at the affective area reveal numerous possibilities for improving student interest, cultural perspectives, and emotional relationships with learning.



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These approaches allow for the relationships between symbols, signs, and cultural tools and engage the students in the construction of mathematical knowledge that solves problems and is critically assessed through representation and meaningful assessment (Ali, 2020; Dolma & Thinley, 2022; Litster et al., 2020). Others help enhance online literacy and interactions, providing students with the tools required in online educational and employment domains (Casadesús et al., 2024). This makes culturally appropriate activities improve interests and relation to students' origins, and culturally appropriate teaching and learning bolster moral standards and profound cultural sensitivity (Samaupan 2019; Kurniasih et al. 2021). Technology-integrated approaches and combined learning models enhance versatility, efficiency, and performance, giving students multiple opportunities to engage with course content and acquire competencies (Fotini, 2019; Sari et al., 2020). These opportunities suggest that the affective domain can also be enhanced reliably and meaningfully if the right approaches are employed in the task process.

Psychomotor

Teaching and learning in the psychomotor domain have some difficulties, especially in teaching techniques. Students do not learn the technical knowledge required to use the mathematical representation; they may have no prior exposure to practical, exploratory work, which may hinder their effective learning (Rivdya et al., 2018). Students' digital literacy can also vary, leading to inequalities, and when physical contact is impossible, the growth of practical skills also suffers (Jia et al., 2022; Alshatri et al., 2019). For designing and implementing psychomotor activities, teachers are confronted with the rigors of choosing appropriate, inquiry-based, and appropriate hands-on activities and including culturally appropriate tasks in light of classroom heterogeneity (Chemlal et al., 2023).

Evaluating psychomotor skills is likewise difficult since conventional tests do not include modern abilities like problem-solving or selection-making in assessing the efficiency of a motor proficiency. While analyzing embodied and material practice and activity across society and technology, it becomes analytically arduous to determine practical ability about digital technology (Mardiana et al., 2020). These challenges mean there is a need to try new ways and means, sufficient resources, and staff development for this learning area to be well managed adequately.

Modern teaching approaches addressing the psychomotor domain offer numerous advantages, fostering hands-on learning and practical engagement that strengthen students' motor skills and problem-solving abilities in mathematics (Rivdya et al., 2018). These approaches align with real-world applications through task-based and collaborative learning, particularly in virtual environments, promoting digital literacy and shared learning practices (Jia et al., 2022). Innovative assessment models enhance practical problem-solving and critical analysis skills, catering to global educational demands (Mardiana et al., 2020).

Integrating culturally relevant tasks fosters inclusivity and deeper engagement, addressing diverse psychomotor needs (Chemlal et al., 2023). Students are encouraged to explore, experiment, and develop creativity, improving their engagement and curiosity in solving mathematical problems (Rivdya et al., 2018). Audiovisual tools and innovative technologies provide interactive and immersive learning experiences, enhancing understanding and making lessons more engaging and efficient (Alshatri et al., 2019). These approaches effectively bridge practical skill development with modern technological advancements, creating a dynamic and inclusive educational environment.

Conclusions and Recommendations

Based on the findings, the study concluded that the global approaches used to effectively address students' cognitive, affective, and psychomotor learning needs and enhance mathematics learning are technology-based, inquiry-based, representation learning, and culturally responsive by promoting skills, interest, and practical application. Using these approaches points to the need to balance the applicative capacities of new technologies with contextual and student-oriented approaches to address students' learning needs. Specifically, findings showed that technology-based learning is the most appropriate teaching strategy for developing cognitive and psychomotor skills when learning mathematical concepts because it provides virtual and controlled settings that foster knowledge assimilation and application. In the affective learning domain, inquiry-based, representation learning, and culturally responsive learning are most effective as they increase students' involvement, learning participation, and thinking through collaborative and blended learning environments.

The challenges in implementing teaching approaches targeting the cognitive domain include limited exposure to representation methods, inconsistencies in knowledge management, poor ICT infrastructure, and weak teacher pedagogy, specifically in implementing inquiry-based learning that aligns with students' backgrounds, which reduces students' engagement. Similarly, in targeting the affective domain, the common struggle was fostering emotional connections, managing student participation in digital learning, and integrating cultural relevance into mathematics teaching and learning processes. Further, the common challenges in targeting the psychomotor domain were skill development, digital or computer literacy gaps, and struggles in assessing practical competencies in traditional and digital environments.

Based on the findings of the study, the following are the recommendations of the study:

- (1) In the teaching and learning process targeting the cognitive domain, integrate multiple representations, including verbal, symbolic, visual, concrete, and situational representations, to help students develop a deeper understanding of mathematical concepts.
- (2) Differentiated and meaningful formative and summative assessments may be designed to assess cognitive skills and emotional engagement, motivation, and self-determination to learn as part of the assessment as learning.
- (3) Technology integration to implement blended learning models to enhance learning flexibility in mathematics education and to develop students' mathematical skills through knowledge assimilation and application.
- (4) In the affective domain, lessons may be developed by integrating culturally responsive teaching and digital tools using relevant examples, real-world applications, and indoor and outdoor activities to enhance student learning engagement and motivation.
- (5) In the psychomotor domain, hands-on, experiential, and task-based learning activities may enhance students' 21st-century skills and practical application of mathematical concepts.
- (6) Further classroom-based research on integrating the suggested teaching approaches of this study is recommended to confirm its effectiveness and effects on students' cognitive, affective, and psychomotor skills and, overall, to enhance mathematics education.



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Declarations

Ethics Statements: This research has followed the ethical standards that are accepted in this journal.

Conflict of Interest: Author declare that there is no conflict of interest in this publication

Informed Consent: All participants have agreed to be involved in this study as stated in the information consent with their real names removed.

Data Availability: All the data collected from the participants test and observation result.

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RESEARCH ARTICLE 13

Efficiency and Contribution to ALS Program Sustainability of Barangay Literacy Workers

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Asia Pacific Journal of Educational Perspectives, 8(1), 79–87

Original publication: 2021

Efficiency and Contribution to ALS Program Sustainability of Barangay Literacy Workers

Asia Pacific Journal of
Educational Perspectives
Vol. 8 No.1, 79-87
May 2021
ISSN: 2782-9332 (Print)

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Date Received: January 11, 2021; Date Revised: April 4, 2021

Abstract – This study determined the level of efficiency and contribution to ALS program sustainability of Barangay Literacy Workers (BLWs) in one of the Divisions of the Department of Education in the Philippines. Employing Descriptive and correlational design and answered the research questions of the study. The respondents were twenty-seven (27) Barangay Literacy Workers, seven (7) immediate supervisors and implementers, and fifty-four (54) Barangay officials. Results revealed that the BLWs were very efficient in survey mapping, learning facilitation, barangay council coordination, and social mobilization of ALS. The higher the BLWs' efficiency, the more number of potential learners will be identified, more learners will be recruited and screened, and consistent monitoring of learner attendance to ensure program completion will be done. Findings suggest to give proper recognition and incentives to BLWs with complete data in terms of mapping survey, the BLWs' honorarium should be increased since they are performing duties that required an extraordinary power and should be given appreciation by DepEd, LGU and Barangay by providing them additional benefits such as giving them insurance that will cover health assistances and security considering that they are working in the field and exposed to hazardous situation.

Keywords – ALS program, literacy, barangay literacy workers, program sustainability

INTRODUCTION

Literacy is one of the most important components to make better people and better world. Knowledge gives every person the courage and confidence to step out from their cocoons, in order to perform their duties and functions as member of the community. Literate people are not afraid to face the challenges, difficulties and changes because they have the complete shield and vest that make them feel secured and globally competitive.

It is clear today: the prosperity in both social and economic terms of human societies around the globe will

depend on the opportunities that individuals have to learn and develop throughout their entire life [1]. According to the human capital theory and studies by the World Bank, one solution to poverty was increasing basic literacy and numeracy skills. It was a simple solution: elegant, obvious, statistically proven and measurable [2]. One of the first four of the United Nation's Sustainable Development Goals 2030 agenda [3] was quality education which aims to increase the number of literate individuals globally.

Allyn [4], the founder of LitWorld, a global literacy initiative that serves children across the world, stated that "It isn't poverty that causes illiteracy, but that it 'steals it,' and that 'every child has the right to literacy. 'Every child should have equal access to books and well-trained teachers. 'It's a human right'. 'Literacy frees you....'"

Literacy is a tool in the new global knowledge market. It opens the doors of individuals for self-development. The development of the country will depend on the number of literates in the society, the growth slowdown as the number of its people with low literacy increases. This illiteracy can hold down the society by preventing it from growing.

This also has an impact on the opportunities of the future generation. For the states and individuals to remain competitive in the global arena, they need to demonstrate an excellent level of literacy. Achieving the SDGs requires partnership of government, private sector, civil society, and citizens to ensure that they leave a better planet for future generations.

The Philippine Government supports the SDGs and has integrated SDGs into their United Nations' Development Plan (UNDP). The United Nations sustainable development vision stated, "We will strengthen the productive capacities of least-developed countries in all sectors". This strongly suggests that the education sector – including education policy makers, ministries of education, and educators – should see other ministries as collegial allies in addressing problems of sustainability.

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Undersecretary Ocampo [5], the DepEd literacy Coordinating Council in charge, in her speech during the 2014 National Literacy Conference and Awards stressed that it is through literacy that one is empowered to interact in his community and realizes his worth, what he can do and eventually make him to do things that contribute in the sustainable development of his society.

Over the years there have been growing concerns on the increasing number of Out-of-School Children, Youth and Adults, particularly in basic education. The report of the United Nations Education Scientific & Cultural Organization (UNESCO) [6] states that Southeast Asian Countries including the Philippines should take urgent steps to enroll out-of-school children, youth and adults, to avoid the economic consequences of having a high number of unskilled work forces in the future. Enrolling out-of-school children, youth and adults is not only a moral obligation of the government, but a productive investment of the state. Based on the data of the Department of Education in 2008, it was estimated that 40.95 million of the total population did not complete basic education, 27.53 million were 15 years old and above, meanwhile 8.7 million were 6-11 years old and 4.7 belong to 12-15 age bracket.

To alleviate the issue of illiteracy in the Philippines, the government has launched innovative programs and projects that addressed the problem. Since every Filipino has the right to free basic education, the government established the Alternative Learning System (ALS) to provide them the chance to have access to and complete basic education in a mode that fits their distinct situations and needs. In addition, the 1987 constitution [7] states that the government should provide for the recognition and promotion of other forms of education other than formal. Article XIV, Section 2 Paragraph 1 and Paragraph 4 declares that: *"The state shall establish, maintain and support a complete adequate and integrated system of education relevant to the needs of the people and society; and concisely encourages non-formal, informal and indigenous learning system, self-learning, independent and out-of-school study programs, particularly those that respond to community needs"*.

The Governance Act for Basic Education otherwise known as the Republic Act 9155 stipulates the establishment of the Alternative Learning System (ALS) to provide out-of-school children, youth and adults population with basic education. There are two major programs in Alternative Learning System (ALS) implemented by the Department of Education, one is the Basic Literacy Program and the other is the continuing Education Program Accreditation and Equivalency

(A&E). Both programs are delivered in modular and flexible system. This means that learning takes place any time and any place, depending on the convenience and availability of the learners using different modules in all subject areas.

Alternative Learning System Non-formal Education happens outside the classroom, community based, usually conducted at the community learning centers, barangay multi-purpose hall, libraries or at home, managed by ALS learning facilitators, such as Mobile Teachers, District ALS Coordinators, instructional Managers and Literacy Volunteers at an agreed schedule and venue between the learners and facilitators.

In Naga City, Alternative Learning System is supported by the local government in the implementation of its programs and projects. Despite its massive education programs and projects campaign against illiteracy, still there are of out-of-school children, youth and adults identified. Based on the 2011-2013 Community Based Monitoring (CBMS) census in Naga City which covered 27,808 household with total population of 131,911, about 9,572 were out-of school, 2,888 age 6-11 were not attending elementary school, 4,536 age 12-15 were not attending high school and the 2,148 age 6-15 were not attending school. This data was very alarming to the local government and the Division of Naga City.

To address the situation, DepEd Naga City thru partnership with the Local Government, Executive Order No.2012-025 [8] dated December 4, 2012 was created to enhance the implementation of the Basic Literacy Program (BLP) and Alternative Learning System (ALS) through directing the appointment of Barangay Literacy Workers (BLWs) in the 27 barangays of Naga City. Dedicated Barangay Literacy Workers (BLWs) are necessary for the effective and efficient implementation of ALS programs and projects.

The functions and responsibilities of Barangay Literacy Workers were to conduct (a) Survey mapping, (b) Learning facilitation, (c) Barangay Council Coordination, and (d) Social mobilization of ALS. Another function is to contribute to the sustainability of the ALS program in terms of (a) Identification of potential learners; (b) Recruitment and Screening of enrollees; and (c) Monitoring of learner attendance and completion. After five (5) years of implementation of the Barangay Literacy Workers (BLWs) Program, the study to assess was initiated.

The guidelines and criteria for BLWs' selection, appointment and deployment and allocation of funds for their honoraria and for other purposes provide clear

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benefits towards enhancement of the implementation of the BLP and ALS and, in general, to the improvement of the quality of education in the city, particularly for the benefit of the poor and marginalized sectors.

In the Pedagogy of The Alternative Learning System: A Philippine Model, Guerrero [9] discussed that Alternative learning as practiced in the Philippines and in other countries is an innovation having a different perspective on learning and how people learn, and what is worth learning. In accordance with the legal mandates of the BALS, an alternative to formal education was developed that is community-based, accessible to all regardless of age, with flexible and non-traditional features, and above all, is equal and parallel to formal school-based education. To further add to the discourse on the relationship between formal education and ALS, UNESCO provides a conceptual framework showing the two (2) learning tracks running side by side and both directed towards a common end goal which is functional literacy and lifelong learning both of which result in employment, social participation and self-actualization.

Field [10] stated that economic factors such as income and employment play an important part in lifelong learning. Toscano et al. [11] also discussed that social outcomes were affected not only by the formal qualification obtained, determined by the education variable, but also throughout the life cycle. Indeed, education and training when undertaken during adult life have a significant impact.

Arko [12] stated in his study that beneficiaries of the functional literacy classes could read, write and do numerical calculations to some appreciable extent at the time of their completion of the course and this helps them in their trading activities. Bakirdjian [13] stressed in his study that Functional Adult Literacy has substantial impacts on the health of participants and their surroundings. It also helps people to improve their use of opportunities to get financial assets and to manage them.

Latchem [14] also concluded in his study that informal learning and non-formal education have a great potential for helping a wide range of learners achieve more desirable and rewarding circumstances for themselves and their communities. Apao et al. [15] stated in their studies that Alternative Learning System A&E program was effective in cultivating the life skills of the recipients. The program improved the quality of living of the respondents as they continue their pursuit for meaning and significance in life. Dayon et al. [16] revealed that through ALS literacy program, the Badjaos had learned to read and write and developed good manners and values of cleanliness and orderliness. They

perceived that the program had built their self-confidence and character, provided them opportunity to improve their socio-economic condition.

Azardon [17] stated that in the Philippines, the rejecting of non-formal education is not so concealed since ALS is called to be the "other side of basic education." There is still the impression that ALS provide low quality education. However, it cannot be denied that through the years, NFE programs like the ALS has generated alternatives in making education more flexible, participatory, transformative and responsive to the circumstances of its learners.

Persoon [18] emphasized that program sustainability is a major issue for many community-based organizations. When a program is not sustainable, the impact of the program is influenced, as it becomes difficult for the program to persist in the long-term. To develop sustainable programs, insight in the factors influencing sustainability is essential.

Ceptuneanu et al. [19] also stressed that Ensuring community-based program sustainability is critical for the targeted communities. When such a program is no longer sustainable, its impact decreases, leading to unmet expectations, affecting the community as a whole. As such, scrutinizing sustainability factors for community-based programs proves essential.

Alternative Learning System is a community-based learning program, DepEd do not provide MOOE for ALS program operation and to sustain its program, support from other local government, other agencies, stakeholders, group of people and private sectors is very important.

Finally, the DepEd Order No. 45, s. 2018 was issued to promote and support the program management activities and capacity-building program for ALS implementers at the regional offices. Expanding and strengthening the ALS program is pursuant to its goal of providing quality, inclusive, relevant, and liberating opportunities to out-of-school children, youth and adult. Thus, funds are allocated to support the regional offices in their ALS-related activities to ensure that the ALS programs are reaching the unreached and the quality of program is based on the standards [20].

Based on the related literatures and studies presented, it cannot be denied that non-formal and informal education offer an answer to solve the educational problems, especially in developing countries like the Philippines, and the big role of the government and other non- government and private agencies and institutions to help sustain and expand this program to

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achieve Education for All (EFA) goals and Sustainable Development Goal (SDGs).

OBJECTIVES OF THE STUDY

This study generally aimed to assess the efficiency of Barangay Literacy Workers (BLWs) in one of the Division of City School of the Philippines. Specifically, it determined the level of efficiency of BLWs along functions, the BLWs perceived contribution to the sustainability of the ALS program, and the relationship between BLWs efficiency along functions and contribution to program sustainability.

METHODS

Research Design

Descriptive and correlational research design was employed to answer the research questions. Descriptive design was utilized to determine the level of efficiency of the BLWs along functions in survey mapping, learning facilitation, barangay council coordination, and social mobilization of ALS; and the perceived contribution to the sustainability of the ALS program in terms of identification of potential learners, recruitment and screening of enrollees, and monitoring of learner and completion. Correlation design was utilized to determine the relationship between BLWs efficiency and contribution to program sustainability.

Respondents

The respondents of the study were the population of twenty-seven (27) Barangay Literacy Workers, seven (7) implementers and immediate supervisors, and fifty-four (54) barangay officials of the ALS program A/Y 2018-2019 of one of the Division of City School in the Philippines.

Research Instruments

To measure the level of BLWs efficiency along functions, a researcher-made questionnaire was designed based on the BLWs job description and qualification released by the authorities. The questionnaire comprised questions regarding the efficiency of the BLWs' functions along survey mapping, learning facilitation, barangay council coordination, and social mobilization of ALS. The questionnaire was critique by the ALS implementer and supervisors for content validity. The instrument was finalized after consideration of the comments and suggestions given by the validators.

Data Gathering Procedure

A letter requesting to conduct of the study was prepared and given to the Schools Division Superintendent of the Department of Education and to the School supervisors for approval. Upon approval, the researchers worked on the preparation, construction, and validation of the research instrument. After the final revision of the questionnaires, data concerning on the BLWs efficiency along functions and contribution to ALS program sustainability were gathered.

The BLWs, implementers, supervisors, and barangay officials answered the questionnaire and the other needed data such as the contributions were taken from the records of the implementers about the BLWS contribution for 2 years. The questionnaires were implemented by interview schedule to ensure that each of the questions was answered properly, ensure reliability and avoid errors.

Data Analysis

Pearson Product-Moment Correlation (r) was employed to determine the relationship between BLWs level of efficiency along functions and BLWs contribution to ALS program sustainability.

Ethical Considerations

Respondents were informed that they were selected purposively as participants and informed consent from them through letter was secured by the researcher. The confidentiality of respondents' scores in level of efficiency and other outputs was assured.

RESULTS AND DISCUSSION

BLWs' Level of Efficiency

The barangay literacy workers' level of efficiency was assessed along survey mapping, learning facilitation, barangay council coordination, and social mobilization. Table 1 shows the BLWs' level of efficiency.

The BLWs were rated very efficient by the respondents. The BLWs were rated highest in Barangay Council Coordination (AWM=3.85) with verbal interpretation of very efficient and lowest in survey mapping (AWM=3.73) also interpreted as very efficient with overall weighted mean of 3.80 interpreted as very efficient. The BLWs manifested the ability to coordinate with immediate superiors, barangay officials regarding issues/concern/progress of the implementation of ALS program. The data showed that BLWs were very efficient in barangay council coordination and was rated highest. It can be inferred that issues, concern, achievement, progress and other matters on ALS program

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implementation, the BLWs directly coordinated with immediate superior and barangay officials for proper intervention, solution and recognition.

Table 1. BLWs' Level of Efficiency

Aspects	IS	BLWs'	BO	AWM	VI
Barangay Council Coordination	3.85	3.82	3.88	3.85	VE
Learning Facilitation	3.92	3.83	3.72	3.82	VE
Social Mobilization of ALS	3.85	3.75	3.81	3.80	VE
Survey Mapping	3.66	3.77	3.74	3.73	VE
Overall AWM	3.82	3.79	3.78	3.80	VE

Note: VE – Very Efficient

Osifo [21] stated that coordination can lead to better organizational performance, organization is best positioned in the form of realizing internally set objectives even with the presence of other competing organizations.

The data further show that overall, the immediate superiors rated the BLWs highest (Overall AWM=3.82) interpreted as very efficient, while the barangay officials rated the BLWs lowest (Overall AWM=3.78) interpreted as very efficient. The BLWs conducted survey mapping to collect consolidate and organized gathered data based on the program and information needed by DepEd ALS and LGU Naga. The BLWs perform function as learner's facilitator to facilitate learner's needs. The BLWs coordinated with barangay official's and immediate superior to consult and address issues, concerns, progress and other matters pertaining to ALS program implementation. The BLWs assisted DepEd ALS, LGU Naga in social mobilization and advocacy to create community awareness on ALS program and strengthened linkages with stakeholders for technical and financial support. The findings revealed that BLWs efficiency in mapping survey, learner's facilitator, barangay council coordination and social mobilization of ALS were evidently observed and monitored by immediate superior and was rated highest. It can be inferred that BLWs expected level of efficiency in conducting survey mapping, facilitating learners, barangay council coordination and ALS social mobilization were met and perceived by immediate superiors.

Similar to the findings of Thao & Hwang [22] that employee performance is the successful completion of tasks by a selected individual or individuals, as set and

measured by a supervisor or organization, to pre-defined acceptable standards while efficiently and effectively utilizing available resource within a changing environment.

In general, it can be inferred that the BLWs were very efficient in barangay council coordination; it was easy for them to coordinate with the barangay council since their official station was the community learning center, situated in or near the barangay hall; and 50 percent of their honorarium was taken from barangay budget.

On the other hand, they were lowest in survey mapping but still verbally interpreted as very efficient. Conducting survey was one of the problems and difficult task given to BLWs. The major problem they encountered during survey was the lack of cooperation of the household members, especially those in the subdivisions. Most of them refused to give information and there were times that the BLWs were not entertained. It implies that the BLWs really needed the help and support of the Barangay Officials, the Local Government of Naga and DepEd Officials to come up with some strategy on how to get the complete data of households in the barangay.

However, in spite of the difficulties encountered, the BLWs' level of efficiency along survey mapping was very efficient. It can be inferred that the BLWs were able to conduct survey mapping very efficiently, collect and consolidate relative data on participation rate of children and youth enrolled in private and public schools, and also able to organize the information they have gathered according to the data asked by Naga City Government, Barangay Council, and DepEd ALS Naga.

The data further showed that on the respondents rating in survey mapping the BLWs themselves rated highest (AWM=3.77) with verbal interpretation of very efficient and rated lowest by immediate superior (AWM=3.66) also interpreted as very efficient. The BLWs conducted survey mapping to gather data of household, out-of-school children, youth and adults and the participation rate both for elementary and secondary level. The findings revealed that BLWs themselves recognized their hard work in conducting survey mapping and was rated highest, the immediate superior rated lowest because the data submitted was not one hundred percent and there was still the need to conduct follow up specially to those households who refused to give information, but still the rating was very efficient, eighty five percent of households were interviewed and surveyed. The immediate superior also considered the problems and difficulties that BLWs encountered in the

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field. It could be inferred that BLWs conducted survey mapping despite of difficulties and challenges they encountered along the field and small amount of honorarium being received.

The BLWs as learner facilitator was rated highest by immediate superior (AWM=3.92) with verbal interpretation of very efficient and lowest rated by barangay officials (AWM=3.72) also interpreted as very efficient. The BLWs facilitate learner's needs and assisted ALS teachers in the community learning. It can be inferred that BLWs efficiency as learner facilitator were directly observed by immediate superior since BLWs assisted ALS teachers and aided learners in the community learning center specifically when ALS teachers are not around. The barangay officials seldom visit BLWs in the learning center because they were more on providing financial and learning materials.

The BLWs level of efficiency in barangay council coordination were rated highest by barangay officials (AWM=3.88) with verbal interpretation of very efficient and rated lowest by BLWs themselves (AWM=3.82) also verbally interpreted as very efficient. The BLWs coordinated with barangay officials and immediate superiors for all the matters regarding ALS program implementation. It can be inferred that barangay officials rated highest barangay coordination because the BLWs official station was the community learning centers located near or inside barangay hall. The barangay officials can easily contact BLWs regarding the issues and concerns on ALS implementation forwarded by BLWs.

Similar to the findings of Charles Osifo [21] that an organization goes with different things that make it broad and complex, understanding coordination as an essential for achieving a balanced organizational performance is ideal. The existence of organizations represents the desire and willingness to fulfil needs. The essential framework for achieving these needs, most times are missing or not given adequate attention. The questions of competition, performance, and expectations are best answered through a good networking of men, material, and ideas.

Table 2. Contribution to ALS program sustainability

Aspects	IS	BLWs	BO	VI
Recruitment and Screening of enrollees	4.00	3.86	3.80	VM
Monitoring of learner attendance and completion	3.87	3.83	3.81	VM
Identification of potential learners	3.85	3.77	3.75	VM
Overall AWM	3.90	3.82	3.78	VM

Note: VM: Very Much

The BLWs' perceived contribution to the sustainability of the ALS program was investigated in terms of identification of potential learners, recruitment and screening of enrollees and monitoring of learners' attendance and completion. All indicators were rated contributed very much by the respondents. Table 2 shows the BLWs' contribution to ALS Program sustainability.

The BLWs were rated highest in recruitment and screening of enrollees (AWM=3.88) verbally interpreted as contributed very much and lowest in identification of potential learners (AWM=3.79) with verbal interpretation of contributed very much, with an overall average weighted mean of 3.83 verbally interpreted as contributed very much. The BLWs helped in the recruitment and screening of potential learners to enrol in ALS. The findings revealed that BLWs contributed very much to the recruitment and screening of enrollees and was rated highest.

The BLWs were lowest in identification of potential learners but still interpreted as contributed very much. It can be inferred that BLWs as bonafide residence of barangay where they were assigned, recruitment of learners was not difficult. The BLWs can easily follow up identified potential learners who were interested to enrol in ALS, as well as on the screening of enrollees because the data was already given during the survey mapping. The BLWs were rated lowest in identification of potential learners because the data was affected by the result of survey mapping. Household survey was not one hundred percent because some households refused to give information; hence, the number of identified potential learners was also affected, but still the BLWs contributed very much in the identification of potential learners.

Congruent to the findings of Holden et al. [23] that collecting less structured data from patients and others in the community is potentially very productive but requires the anticipation, avoidance, or negotiation of various challenges.

Furthermore, data show that on the average, the BLWs' contribution to ALS program sustainability was rated highest by the immediate superiors (overall AWM=3.90) verbally interpreted as contributed very much and rated lowest by barangay officials (Overall AWM=3.78) with verbal interpretation of contributed very much. The BLWs helped in identification of potential learners, recruitment and screening and monitoring of Learners' attendance and completion as perceived by the respondents.

The findings revealed that BLWs contributed very much in identification of potential learners, recruitment

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and screening and monitoring of attendance and completion as rated by the respondents specially the immediate superior who rated highest. It can be inferred that immediate superior who monitored and collected the data in terms of identified potential learners, number of enrollees, passers and completers submitted by BLWs in their respective barangay, can attest that BLWs contributed very much on the said indicators pertaining to the BLWs perceived contribution to ALS program sustainability.

Table 3. Significant Relationship between BLWs' Efficiency and Contribution to Program Sustainability

BLW Efficiency	Contribution to Sustainability	r-value	p-value
Survey mapping	Identification of potential learners	.876**	.000
	Recruitment and Screening of enrollees	.731**	.000
	Monitoring of learner attendance and completion	.895**	.000
	Overall	.869**	.000
		.914**	.000
Learning facilitation	Identification of potential learners	.914**	.000
	Recruitment and Screening of enrollees	.778**	.000
	Monitoring of learner attendance and completion	.916**	.000
	Overall	.906**	.000
		.824**	.000
Barangay Council coordination	Identification of potential learners	.824**	.000
	Recruitment and Screening of enrollees	.801**	.000
	Monitoring of learner attendance and completion	.873**	.000
	Overall	.866**	.000
		.817**	.000
Social Mobilization of ALS	Identification of potential learners	.817**	.000
	Recruitment and Screening of enrollees	.748**	.000
	Monitoring of learner attendance & completion	.915**	.000
	Overall	.859**	.000
		.927**	.000
Overall		.927**	.000

**Significant at $p < .001$

The significant relationship between BLWs' efficiency and contribution to ALS program sustainability was computed. Table 3 shows the computed r and p-value.

Results show that all aspects of BLWs' efficiency were significantly correlated with all aspects of contribution to ALS program sustainability indicated by $p = .000$. Specifically, the computed r-value of survey mapping and identification of potential learners, recruitment and screening of enrollees, and monitoring of learners' attendance and completion were $r = .876, .731$, and $.895$ with over-all r-value of $.869$ respectively, all with p-value of $p = .000$ interpreted as significantly correlated.

Similarly, the computed r-value of learning facilitation and identification of potential learners, recruitment and screening of enrollees, and monitoring of learners' attendance and completion were indicated by $r = .914, .778$, and $.916$, respectively with over-all r-value of $r = .906$, all with p-value of 0.000 interpreted as significantly correlated.

Likewise, the computed r-value of barangay council coordination versus identification of potential learners, recruitment and screening of enrollees, and monitoring of learners' attendance and completion were $r = .824, .801$, and $.873$, with over-all r-value of 0.66 respectively, all with p-value of 0.000 interpreted as significantly correlated. Then, for the computed r-value of social mobilization of ALS versus identification of potential learners, recruitment and screening of enrollees, and monitoring of learners' attendance and completion were $r = .817, .748$, and $.915$, respectively with over-all r-value of $.859$, all with p-value of 0.000 interpreted as significantly correlated. The over-all computed r-value of $.927$ and p-value of $p = .000$.

It means that there was positive direct relationship between BLWs efficiency and contribution to ALS program sustainability. The findings revealed that the more the BLWs became efficient the more they can contribute to ALS program sustainability. It can be inferred that BLWs efficiency in mapping survey, learning facilitation, barangay council coordination and social mobilization of ALS were significantly correlated to identification of potential learners, recruitment and screening of enrollees and monitoring of attendance and completion sustainability.

The BLWs efficiency in survey mapping has a significant relationship with the number of identified potential learners. The number of identified potential learners will depend on the number of household mapped. The BLWs efficiency as learner's facilitator, motivated learners to report to community learning center on their scheduled learning session, and inspired learners to attend learning intervention, that sustained learners' attendance and completion. The sustainability

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of ALS enrollees, completers and passers had a significant relationship with BLWs efficiency in barangay council coordination and social mobilization, knowing that ALS program implementation would only be successful if there were support from barangay council, stakeholders and other agencies. The technical and financial support really mattered in ALS program operation because DepEd do not provide ALS MOOE, and that would only be realized through constant coordination and intensive social mobilization and advocacy.

The finding is congruent to the study of Sabbil and Adam [24] which revealed that the project has facilitated participation of local communities in development initiatives in the study area, encouraged residents to take ownerships of their own community resources, enhanced partnerships between the local community and the government or nongovernmental organizations. The results revealed that despite the withdrawal of the foreign assistance, the project existed and performed some activities due to effective stockholders' participation.

Identification of potential learners, recruitment and screening, increased the number of enrollees, monitoring of attendance of learners increased the number of completers and passers. The number of enrollees, completers and passers are the key performance indicators of ALS program implementation. The target number of enrollees was obtained through identified number of potential learners, harvested from the result of survey mapping. The target number of completers and passers attained through learning facilitation and constant monitoring of attendance and completion. Effective implementation of ALS program was achieved because of the technical and financial support gained from barangay council, other agencies and stakeholders, which was realized through intensive coordination and ALS social mobilization.

CONCLUSION AND RECOMMENDATION

The BLWs were very efficient in survey mapping, learning facilitation, barangay council coordination, and social mobilization of ALS. BLWs conducted mapping survey accurately no matter how hard it was, facilitate learning very well to encourage the learners to complete the program, coordinated with barangay officials accordingly for technical and financial support to provide the needs of the learners and implement the ALS program appropriately and conducted social mobilization to raise awareness in the community and gain support from other agency and stakeholders to the ALS program. The BLWs identified potential learners

precisely, recruit and screen enrollees properly and monitor learners attendance and completion consistently that contributed very much to ALS program sustainability. The higher the BLWs' efficiency in mapping survey, learning facilitation, barangay council coordination and social mobilization, the more number of potential learners will be identified, more learners will be recruited and screened, and consistent monitoring of learner attendance to ensure program completion will be done.

Based on the findings, the following are highly recommended: Give proper recognition and incentives to BLWs with complete data in terms of mapping survey. The City Government in the collaboration of DepEd ALS should think of better strategies on how to get the one hundred percent participation of households in mapping survey, and to determine the actual number of out-of-school and illiterate in the City. The actual data will help DepEd and the City government to figure out what program particularly in ALS will be given additional funds. The BLWs honorarium should be increased since they are performing duties that required an extraordinary power. More funds should be given to ALS to implement the program widely and effectively and to cater to all potential learners and be given proper intervention based on the result of screening and assessment conducted. The BLWs' should be given appreciation by DepEd, LGU and Barangay by providing them additional benefits such as giving them insurance that will cover health assistances and security considering that they are working in the field and exposed to hazardous situation in the community. Other programs such as establishment of BLWs personal development plan to continuously improve skills and efficiency can also be implemented.

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RESEARCH ARTICLE 14

A Participatory Action Research (PAR)-Influenced Mentoring Program for Graduate Students

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The Palawan Scientist, 14(1), 1–10

Original publication: 2022

A participatory action research (PAR)-influenced mentoring program for graduate students

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Received 26 April 2021 || Revised 21 November 2021 || Accepted 17 March 2022

ABSTRACT

The study described a mentoring program of a state-funded research and its effects on research and reflective practices to graduate students. Participatory Action Research (PAR), designed as a methodical and program framework, engaged nine mentors (researchers of a state-funded research) and 29 graduate students (purposely invited) to training-based mentoring (workshops and field work), small group mentoring (within research cells), and peer mentoring (field work and software-aided coding analysis). Observations, mentors' narrations, and reflection journals extracted the experiences of the participants on the mentoring program. These reflections revealed that mentors and mentees learned many skills in the mentoring program. They had transformed challenges and difficulties (time management, field work) into learning episodes leading to reflection-in-action and reflection-on-action. They realized the importance of the theory-practice-reflection paradigm in all research endeavors. Hence, PAR-influenced mentoring helped develop their research skills. However, low engagement of the others may be due to time aspect, which may be looked into in a replicated study.

Keywords: collaborative practice and action, learning episodes, reflective-practitioner, research skills

INTRODUCTION

As a response to the Fourth Industrial Revolution era (FIRE) and as a new education paradigm that could deal with the new disruption and uncertainty brought about by the global pandemic, Education 4.0 (E4.0) envisions knowledge-based economy, high global competitiveness index, and provision for continuity of learning (OECD 2018). Two key drivers of E4.0 that influenced most countries are: 1) quality Science, Technology, Engineering, Mathematics (STEM) education, and 2) a strong system of graduate education (Current trends in higher education 2014). This new-found core of graduate education seeks to develop professionals who are both knowledgeable (advanced knowledge) and skilled (soft skills: capability to lead, a team player, and is terms of quality (Conchada and Tiongco 2015). Thus, efforts gear towards improving the graduate programs

able to communicate). Thus, the thrust focuses on investing in graduate education and research infrastructure in the field of STEM, which most closely influence FIRE.

The 2017-2022 Philippine Development Plan (NEDA 2017) and quality assurance in higher and advanced learning (CHED 2012) assert a competitive higher education in the country. However, a low completion rate is still evident. Data shows that only 41% of the 656 state universities and colleges (SUCs), and 23% of the 1,643 private higher education institutions (HEIs) have graduate programs. A skewed distribution of post baccalaureate programs is observed where the majority of program offering clumped on Education (35%), Business Administration (9%), and Nursing (9%) (Ofreneo 2014). These top programs ranked fair or poor in through a holistic development of students as professionals and academicians.

The concept of mentoring is anchored on several theories and has begun inching in the graduate education system to assist students to overcome related challenges and difficulties. These theories include stable and transitional periods as keys of the life cycle (Levinson 1986) and developmental theory by Freud, Jung, and Erickson (Dominguez and Hager 2013). Additionally, Kegan's theory focuses on transformative learning where the learner encounters the distinct stages of experiences (McGowan et al. 2007). Kram (1985) espoused multiple and simultaneous mentoring methods (traditional mentoring, group mentoring, peer mentoring), exemplifying the importance of mentoring relationships. This relationship may be enhanced through Appreciative Inquiry (AI) that identifies and cultivates the best in people through the art and practice of asking questions that strengthens a person's capacity to apprehend, anticipate and improve their potential (Stratton-Berkessel 2020).

This study emphasized peer and group mentoring models (Darwin and Palmer 2009) which require the mentee to remain open to unlearning old skills and learning new ones. Compared to the traditional paradigm of knowledge transfer and wisdom-passing from old to young (Darwin 2000), the model supports Higgins and Kram (2001) concept of mentoring as a development of diverse mentoring relationships or networks, where the mentor acts as a guide (Zachary and Fischler 2009).

Apparently, graduate mentoring in most institutions in the Philippines differ from what universities in other countries perpetuate. In other countries, a supervisor is assigned to a graduate student upon acceptance to the graduate program. This early engagement of the graduate student in choosing the research topic helps widen the reach of the student to available expertise, research trends and standards (Tanhueco-Tumapon 2016). Thus, the current study details how the current model observed in most Philippine institutions of higher learning may be supplemented through research immersion of graduate students by voluntary engagement in research work of the university even before they enroll in their terminal courses. These supplements encourage expansion of the view and practice of mentoring in the graduate program to start from enrolment to graduation. This schema also provides students with the opportunity to expand workforce development as a responsibility of community engaged research groups (Arrieta et al. 2018) and may help improve students' perceptions of research (Kiersma et al. 2012).

While these theories highlight mentoring, a minority of such studies traces mentoring in the fields of graduate education in the Philippines. In other countries, the use of participatory action research (PAR) as a mentoring framework has been articulated on few occasions (Burke and Hadley 2018). PAR roots on the general attributes of Action Research (AR) that

includes participatory character and reflective practice (Kemmis and McTaggart 1988), implemented in mentor education as part of professional development (Aspfors and Fransson 2015). PAR seeks to bring theory and practice, in participation with others, in pursuit of practical solutions to issues of pressing concern to people (Reason and Bradbury 2008) and equality of participants through participation and action (Morales 2019).

Mentoring goes beyond unlearning and learning. It may be attributed to a two-way development of Technological-Pedagogical-Assessment-Content-Knowledge (TPACK) system of mentor and mentees. TPACK describes the acquisition and demonstration of instructional experiences integrating content, pedagogy, and technology in establishing effective instructional practice and environment (Koehler and Mishra 2008), which exemplifies concrete steps of mentor education (Aspfors and Fransson 2015). AI puts a more human perspective on the program, being grounded on positive psychology focusing on the strengths of people and what works well in co-designing their future (Tocino-Smith 2020). Thus, this study designed a mentoring program for graduate education courses in Science, Technology, Engineering, Agri/Fisheries, Mathematics (STEAM) grounded on PAR framework and AI approach to supplement the course and research works of graduate students. Specifically, the study sought to: 1. Describe the mentoring program for graduate students; 2. Describe the development of collaborative practice or action; and 3. Identify the benefits of the mentoring program on research skills and reflective practice.

METHODS

Research Design

The study documented the mentoring program of a state-funded research on the TPACK of Philippine tertiary teachers of courses in STEAM. This state-funded research is a collaboration of 10 (7 state universities and colleges [SUC], namely, Philippine Normal University as Lead Institution, Mindanao State University – Iligan Institute of Technology, Polytechnic University of the Philippines, University of the Philippines Manila, University of the Philippines Los Banos, Batangas State University, and West Visayas State University, and 3 private universities, namely, De La Salle University, Jose Rizal University, and Manuel S. Enverga University Foundation) higher education institutions (HEIs) in the country. Figure 1 shows that the mentoring framework designed using multiple cases labeled as the research cells. The PAR was utilized as methodical framework to implement a mentoring program to volunteer graduate students. The framework emphasized the mentors' (researchers from the 10

collaborating HEIs) and the graduate students' varying roles that defined how the latter may have acquired meaningful and rich learning experiences and how the former emphasized working on AI to draw positive outcomes from the participants. Grounded on PAR and AI, the program supplements the formal supervisor-advisee paradigm to help the latter complete the research requirement of their graduate programs.

Components of Graduate Programs under the State-Funded Institution

Typically, graduate programs in the Philippines include several academic courses with thesis as a terminal course for degree completion. Table 1 shows the course distribution for graduate programs in the lead institution of the state-funded research.

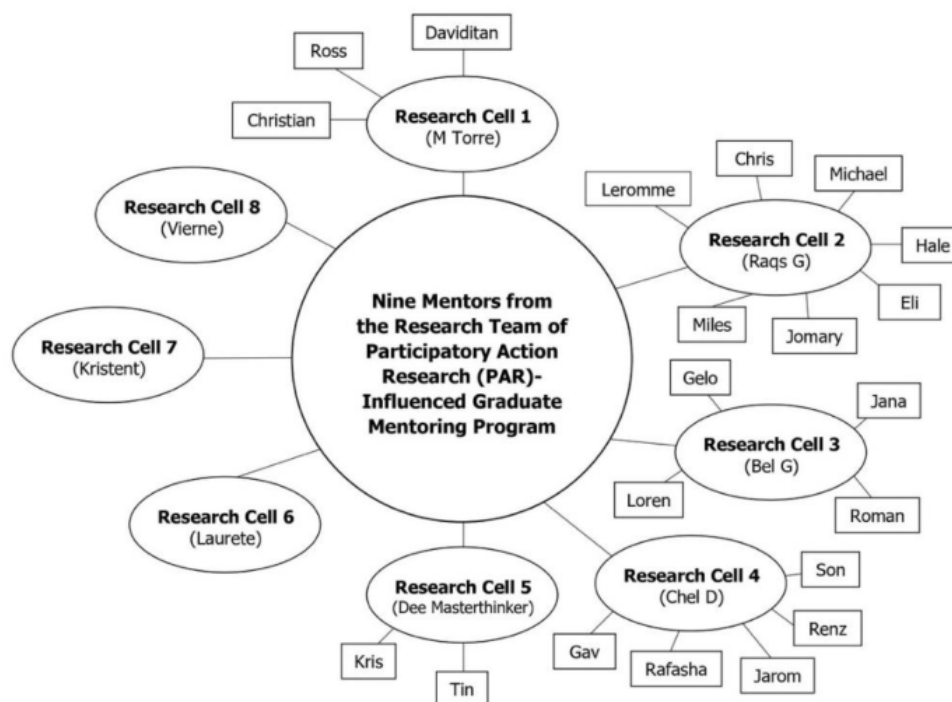


Figure 1. PAR-influenced mentoring framework for graduate education [names are pseudonyms]. The participants in oblong cell (senior mentees) were the first batch mentored by the nine researcher mentors, while in the rectangle cells (junior mentees) were the second batch mentored by the senior mentees.

Table 1. Program components and course distribution of graduate programs in the Lead Institution.

Components of the Programs	No. of Units	
	MA	PhD
Core Courses	9	12
Electives	3	6
Specialization Courses	18	24
Thesis/Dissertation	6	12
Foreign Language	0	6
TOTAL	36	60

Participants

A total of nine mentors (researcher from the 10 collaborating institutions of the state-funded research) and 29 graduate students (from the 10 collaborating institutions with names of the participants in this study as pseudonyms) were the participants of the mentoring program (Figure 1; Table 2). The first batch of mentees that included eight graduate students were purposively selected from the lead institution (Table 2).

The selection criteria include being currently enrolled in a dissertation course, working on his/her dissertation, and is a science/math education graduate student. These eight graduate students were labelled as the 'senior mentees' in Table 2 that defined each research cell in the study based on the methodical framework (Figure 1). These eight senior mentees had expressed their willingness to be part of the mentoring program (in their commitment forms) as supplement to the formal supervision by their official course (dissertation writing) supervisor. Permission was also sought for such an arrangement from the administration of the lead institution. The second batch of mentees included 21 graduate students who were in the different fields of STEAM education and mass communication programs and were active graduate students in any of the 10 collaborating

institutions of the state-funded research. These second batch tagged as the 'junior mentees' in Table 2 populated five of the oblong cells (Figure 1). To qualify, the research team used the same selection criteria as aforementioned. They voluntarily signified their interest to join the mentoring program through the commitment form. They were also aware that the mentoring program is only ancillary to the formal supervision by their respective supervisors.

Instruments

Graduate mentoring reflection template/form. The form contained 11 questions. Four questions focused on the gained insights/learning of the mentees regarding their involvement in the mentoring program. The other seven questions highlighted their professional learning as they reflected on the whole research activity.

Graduate mentoring handbook. The handbook highlights salient information about how the mentoring program began, the pedagogical framework used in implementing the mentoring program, resources, policies, data collection instruments, guidelines for apprenticeship and the reflection templates by the mentees after their attendance in the different activities within the aforementioned state-funded research.

Table 2. Mentors and participants of the study in Participatory Action Research (PAR)-influenced mentoring program.

Nine Mentors from Research Team	Senior Mentees/Mentors in each Research Cells (PhD Science Education)	Junior Mentees	Program
Mentor 1 [M1] Mentor 2 [M2] Mentor 3 [M3] Mentor 4 [M4] Mentor 5 [M5] Mentor 6 [M6] Mentor 7 [M7] Mentor 8 [M8] Mentor 9 [M9]	Laureante	No junior mentees	
	M Torre	Ross	PhD Science Education
		Christian Dadivitan	MA Science Education
	Raqs G	Leromme	MA in Information and communication
		Chris	MA in Mathematics
		Michael	
		Hale	MA Science Education
		Eli	
		Jomary Miles	
	Bel G	Gelo	PhD Science Education
		Loren	
		Roman	
		Jana	
	Dee Masterthinker	Kris Tin	MA Mass Communication
	Chel D	Gav	MA Science and Mathematics Education
		Rafasha	
		Jarome	
		Renz Son	
	Kristent Vierne	No junior mentees	

Data Collection

Senior graduate mentees. The research team (mentors) documented the implementation of the entire mentoring program. In the implementation, recruitment of graduate student volunteers commenced before the data collection stage of the aforementioned state-funded research. The team first invited eight graduate students (senior mentees specified in Table 2) to join the meetings attended by the researchers of the aforementioned state-funded research, which also served as the invitees' immersion activity before their formal orientation to the project and to the mentoring program. After consent, the team oriented these senior mentees on the details and phases of the state-funded research. The team also sourced the challenges and difficulties the senior mentees are currently encountering in their research work and determined which research skills they want to learn or enhance. Upon consolidation of their needs, the research team presented the mentoring program from where these senior mentees could source knowledge and address their identified difficulties. Based on these needs, the research team conducted trainings on how to utilize the research instruments and discussed all requisites to data gathering (e.g. forms, allowances, allowable expenditures, government issuances on liquidation process and travel) procedures. There were free seminars/workshops (conducted in two to three days, in about five workshops) to train the senior mentees on interviewing, transcribing, and software-aided coding analysis. The research team (mentors) also provided the details of on-site transactions during the scheduled school visits for the state-funded research (data collection phase). Note that the program is not focused on assigning a specific mentee to a mentor, but each of the members of the research team is believed to be able to contribute as a mentor.

In order to develop collaborative practice and action and to identify the benefits of the mentoring program on research skills and reflective practice, the research team sent these senior mentees to actual field research works to collect country-wide data. The senior mentees were asked to accomplish the Graduate Reflection Template/Form for every assignment/deployment. They were also subjected to journaling technique as an approach to get an in-depth information about their experiences and challenges to describe and map the connections of their experiences in the mentoring program. Their journal entries were compiled for documentation and analysis.

Junior graduate mentees. Since the state-funded research requires nation-wide data, the team sourced new recruits (junior mentees) following the same selection criteria. For this second batch, the senior mentees served as immediate mentors to the junior volunteers (junior mentees). The senior mentees simulated all processes to formally orient the new batch of mentees (21, with eight active field

researchers in the project). Here on, five research cells (Figure 1) were formed by assigning junior mentees to senior mentees. The senior mentees conducted tutorials (within their research cells) on how to administer interviews, classroom observation, and transcribe and implement software-aided coding analysis. With the PAR framework, the research team (mentors) coursed through assignments to field works to the senior mentees who communicate to their junior mentees within their research cells all pre-requisite data and processes needed for the conduct of the field work. The senior mentees also permitted the junior mentees within their research cell to work collaboratively with other members of the research team (mentors) and the other junior mentees who are assigned on the same field work. In detail, the research team involved the senior mentees in five out of seven components of the state-funded project. While the junior mentees concentrated on aiding the research team in terms of data gathering (three components of the project).

Data Analysis

The research team collated all graduate students' reflections through software-aided MAXQDA 2018 (VERBI Software 2019) coding analysis. Meticulous transcription, organization of responses, and abstractions were done on the reflections sourced from the accomplished templates. The transcripts were reviewed for errors and are read several times to immerse with the details of the interview before coding. Statements were broken into parts, gave prior meaning to codes, and noted the frequency of code occurrences. Finally, the research team assigned memos to the identified code system, to include the statements of the participants and finally crafted emergent themes from the constructed cluster of ideas.

RESULTS

The themes generated from the analysis match the three priori constructs: mentoring, collaborative action and practice, and benefits of the mentoring program.

Mentoring Program

The mentoring program trained six of the eight (75%) senior mentees for the first round of data collection (February to December 2018) and 21 junior mentees for the second batch of mentoring (January 2019 - March 2019) (Table 3).

The mentoring and training activities in each research cell enabled transfer of technology (interview strategies, data collection approaches, correspondence to other officials, coding and data analysis), and

upskilled members of each of the research cells through peer mentoring.

Collaborative Practice and Action

Table 4 shows the abstraction process done on the coded responses leading to the theme, collaborative practice and action. This abstraction process denotes that their challenging experiences (e.g. test of self-confidence) are stimulants of action and collaboration to counter these struggles.

Benefits of Mentoring Program on Research Skills, and Reflective Practice

Table 5 shows that the thematization of one of the prior constructs labeled as benefits of the mentoring program on research skills and reflective practice, emphasize three major categories that feature reflective-practice. As shown, the three categories cover a wide range of competencies of teacher-researcher which include technological capacity, research skills and professional and personal enhancement.

Table 3. Training and activities in mentoring program for senior and junior mentees.

Senior Mentors (pseudonyms)	Junior Mentees	Training and Mentoring Activities
Raqs G	7	- Batch 1 of Field work (February to December 2018) - Attendance to all the five 2-3-day workshop (be the research team on different topics in research) - Mentoring sessions of and constant communication (through face-to-face, short-messages, email or social media) with junior mentees - Batch 2 of Field work (January 2019 - March 2019)
Bel G	4	
M Torre	3	
Chel D	5	
Dee Masterthinker	2	
Laurente	0	- Field work (February to May 2018) - Attendance to all the five 2-3-day workshop (be the research team on different topics in research)
Kristent	0	
Vierne	0	- Attended 1 of 5 workshops - Had administrative tasks leading them to forego the program
TOTAL	21	

Table 4. Abstraction of coded responses of participants leading to the category, 'collaborative practice and action'.

Sample verbatim responses	Code (f=frequency)	Category	Theme
"My blood ran cold as I initially faced them, but eventually I realized that I have to establish confidence doing it." [M Torre].	Test of self-confidence (f=12)	Challenges to address	Collaborative Practice and Action
"I stuttered and still felt nervous in asking questions during the interview." [Laurente]			
"In the interview phase, I had difficulty communicating the questions to the respondents since they have different perspectives or frame of reference, that is why I had to simplify the questions and give more probing questions."			
"They (students in the participating institutions) speak in their own language [dialect or L1], and their teacher allowed them, so I was not able to understand the content because of the language barrier" [Bel G].	Use of dialect (f=12)	Action and collaboration	
"Since my mentees were also employed and are also enrolled in their thesis writing, we all had difficulty in attending field works and scheduled meetings." [Dee Masterthinker]	Time management (f=4)		
"I think you should practice more on conducting the interview." [Mentor I].	Practice (f=9)		
"I was happy to learn that I had mentees who successfully and actively participated in the field work." [Raqs G].	Participate, contribute (f=4)		
"I feel proud that I was able to contribute to improving the research skills of the members of my research cell, and this also developed me as a researcher and mentor as well" [M Torre].			

Table 5. Benefits of the mentoring program on research skills, and reflective practice of the participants.

Sample verbatim responses	Code (f=frequency)	Category	Theme
"preparing, data gathering in a qualitative research instruments to be prepared. Instrument to be accomplished and signed prior to the interview like the consent form" [Dee Masterthinker]	Skills in qualitative research instruments (f=15)	Technical improvement	Benefits on Research Skills, and Reflective Practice
"workshops greatly help and develop my skills in coding qualitative data that easy"... We learned the nitty-gritty of qualitative research work. We get involved in transcribing and coding. I learned a lot. Memoing of the significant data, deciding what mother code can we make. These tasks helped us to be mindful of all the mother codes that we assign so that, it will be easier for us to do the coding and assigning daughter code" [M Torre]	Skills in coding (f=15)		
"It gears up my research skills and gives me confidence in doing qualitative research", "my skills as a qualitative researcher was honed" [M Torre]. "I was given the chance to apply the theoretical skills knowledge I acquired during the program. I was able to see the real picture of qualitative research, and challenges and problems of conducting qualitative study" [Bel G] "I would like to enhance my skills in conducting research and to be more involved in projects like this" [Laurente].	Improvement of research skills in general (f=15)	Research Skills improvement	
"I am looking forward to more productive research engagements with my learning institution to deliver quality research services to my future students" [Raqs G]. "The knowledge I gained during the mentoring process will be very helpful when I will be conducting my researchers. During the mentoring, I learned about the protocols in conducting interviews and classroom observations" (2) [Bel G]. "Honestly, my experiences were beyond words. On a personal note, it was indeed a meaningful and memorable academic learning endeavor" [Raqs G].	Learnings of participants (f=15)	Professional development and personal improvement	
"As a teacher, the experience and knowledge I gained from my involvement in this project and mentoring program will help me improve my teaching skills. As a research teacher, I could also see these to give more meaningful classroom discussions with my students." [Laurente]	Improvement of teaching of research skills (f=4)		
"Content upgrading is what we have drawn from the use of technology in research, and the learning derived from interacting with fellow STEAM educators." [Bel G].	Content upgrading (f=10)		

DISCUSSION

The study described a PAR-influenced mentoring program that highlights research cells as the unit skills improvement. Abstractions and thematization led to themes parallel to the aforementioned priori constructs.

Mentoring Program

In the mentoring program, Kegan's theory on the distinct stages of experiences (McGowan et al. 2007) was visible. The mentees in the early development stage might expect a mentor as a guiding authority, while more advanced mentee might prefer a

mentor who questions deep-seated beliefs and engage them in reflective and progressive development (Dominguez and Hager 2013). Apparently, the mentoring program had reached this state in the different levels of mentoring within the research cells. In fact, multiple and simultaneous mentoring methods (traditional mentoring, group mentoring, peer mentoring), exemplifying the importance of mentoring relationships (Kram 1985) and emerging varied bonds were vivid in each research cell. A system of transfer of technology and knowledge empowering the participants (Darwin 2015) through the participatory nature of the program that evolves developmental approach (Feldhaus and Bentrem 2015) and peer mentoring (Khoo et al. 2019) were evident. Raqs G, a senior mentee claimed, "I was happy to learn that I had mentees who successfully and actively participated in the field work". Everyone, from mentors to junior mentees, engages in the rigors of theory-practice-reflection (Morales 2019) in the different forms of mentoring imbedded in the program (e.g. a resource-based, group mentoring, training-based, and executive mentoring) (Reh 2019).

Collaborative Practice and Action

The participants encountered challenges and difficulties forcing them and the team to take action, which, then led to opportunities for collaborative practice for research implementation (Lodge et al. 2018). In fact, these encountered challenges and with the objective assessment of mentors, initiated practice and simulations within the research cells (either face-to-face or online) strengthened their bonds within their respective cells to practice collaboration and participatory contribution. AI by the mentors may have helped the participants transform these challenges to positive perspectives (Won and Choi 2017). An example, one of the mentors blatantly expressed, "I think you should practice more on conducting the interview" to his group while on board a field work. Evidently, collaborative learning and practice, which include celebrating, setting goals and reflecting on progress, peer teaching, critiquing and revising, and problem solving (Martin 2017) were manifested in each research cell and demonstrated the ideals of participatory framework that showcase reflective practices (Morales 2019). In fact a senior mentee [M Torre] claimed, "I feel proud that I was able to contribute to improving the research skills of the members of my cell and this also developed me as a researcher and mentor."

Benefits of Mentoring Program on Research Skills, and Reflective Practice

As teachers, all mentees were able to enhance their professional practice and research skills. They value the "technical improvement" and enhancement

of their research skills by building their confidence in doing qualitative research and analysis (Kiersma et al. 2012). Their reflections implied that the program may have provided them the nexus for bridging theory and practice of research (Joubert and de Villiers 2015). They also considered "professional improvement" that highlighted their professional development through protege orientation. Evidently, there were good and strong mentor-mentee relationships that motivated mentees for productive research engagement. Holistically, the individual benefits that the participants derived from the project created their positive outlook towards research, notwithstanding the fact that their respective research cells instituted activities and relations that instigated skills improvement of both the mentors and the mentees. Overall, they attested that they were retooled and were able to sharpen their skills and felt that the mentoring program somehow impacted their character as teacher-researcher (Table 5).

Finally, the participants believed that they gained pedagogical knowledge improvement through country-wide exposure to the real conditions of research and education in STEAM programs.

These results imply that PAR as a methodical and program framework established a structured mentoring program beyond the scope of adviser-advisee mentoring, exemplifying collaborative learning, practice, and action. The program engaged all faculties—physical, emotional, socio-cultural, and psychological—of mentors and mentees leading to reflective and reflexive actions that might have developed a habit of mind and a reflective and reflexive culture. The activities within the mentoring program value the triangulation of theory-practice-reflection that helped the graduate students enhance their research skills and become good field researchers for the state-funded research.

The study is a documentation of a mentoring program of the state-funded research that reports a rich set of experiences of mentors and mentees. However, data collection may include video/audio recording of field observations for the mentoring process to capture all data sourced from the volunteers as mentees. PAR as a methodical and program framework may augment and complement professional learning and continuing professional development programs with an aspect of a micro-credentialing system in graduate school in-service field.

ACKNOWLEDGMENTS

This work was supported by the Commission on Higher Education on the basis of the Commission en Banc Resolution Number 245-2011 "Technological-Pedagogical-Assessment-Content-Knowledge (TPACK) in STEAM Education". The team would also like to acknowledge the reviewers for

their valuable comments that helped the team improve this manuscript.

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The Palawan Scientist, 14(1): 1-10
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ROLE OF AUTHORS: *MPEM* – Lead researcher, paper conceptualization and writer of article; *CPP* – researcher, mentor, paper conceptualization, and writer of article; *RAA* – researcher, mentor, paper conceptualization and writer of article; *JCA Jr.* – researcher, mentor, paper conceptualization and writer of article; *LEE* – researcher, mentor, paper conceptualization and writer of article; *TOA* – researcher, mentor, paper conceptualization and writer of article; *BRB* – researcher, mentor, paper

conceptualization and writer of article; *ECA* – researcher, mentor, paper conceptualization and writer of article; *RDS* – researcher, mentor, paper conceptualization and writer of article; *RPB* – researcher, mentor, paper conceptualization and writer of article; *FMM* – researcher, mentor, paper conceptualization and writer of article, Language Editor; *MDG* – participant, senior mentor, writer of article; *MOT* – participant, senior mentor, writer of article; *RAG* – participant, senior mentor, writer of article; *NAC* – Data consolidation.

RESEARCH ARTICLE 15

Student Perception of Science as Influenced by Spark Science Learning System (SSLS)

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Acta Didactica Napocensia, 11(1), 87–99

Original publication: 2018



STUDENT PERCEPTION OF SCIENCE AS INFLUENCED BY SPARK SCIENCE LEARNING SYSTEM (SSLS)

Maribel D. Ganeb, Darryl Roy T. Montebon

Abstract: The present research explores the perception of students on their use of the SPARK Science Learning System device and sensors in their science classes as they study the K to 12 science modules in the Philippines. Two groups of students were assigned to be the experimental and the control group of the study. The experimental group was exposed to the SPARK Science Learning System and the other group was not. To determine the perceptions of both groups on their science classes, the instrument, iKnow My Class Survey was utilized. Upon analysis, it has been found out that the difference in the pre-test mean and the post-test mean on the survey conducted was statistically significant with a p-value of less than 0.05 ($p\text{-value} = 0.019 < 0.05$). Thus, it can be concluded that the use of SPARK Science Learning System incurred better perception of science classes among students.

Keywords: SPARK Learning System, ICT in the classroom, Perception

1. Introduction

A significant change was implemented in the Philippine education system—the K to 12 Program. The Enhanced Basic Education Curriculum or the K12 Curriculum was carried out by virtue of Republic Act (RA) 10533 in 2012. In particular, the Science program under the K to 12 experienced major reforms: decongestion of topics, inquiry based instruction, contextualization of lessons, and the spiral progression of competencies. All of the described reforms are to develop as scientifically literate citizen.

The change in the curriculum influenced different perspectives among its stakeholders. First, students perceived the K to 12 program to help them become holistic individuals (Montebon, 2014). Second, parents view the K to 12 curriculum to have good and bad impacts to their way of living (Cabansag, 2014). Lastly, teachers see the curriculum to help students for the challenges of the 21st Century (Tuga & Montebon, 2017).

Though the change in curriculum influenced different perceptions in the K to 12 program, the present research introduces a method how to help students survive in the new curriculum—through the use of SPARK Learning System (SSLS) in science. Using SSLS as technology in science is hoped to aid science teaching and learning; since, technology help students develop positive perceptions towards the discipline. Studies also reveal that the nature of the learners nowadays is inclined towards technology, thus using technology in the classroom helps them achieve better (Morales, 2014; Clark, 2010; Auditor & Roleda, 2014).

The findings of this study could be an indicator to educators to continuously utilize SSLS as an instructional tool in science. The interest of the learners may lead to positive outcome wherein they

Received 5 June 2016, accepted 16 March 2018.

Cite as: Ganeb, M. D. & Montebon, D. R. T. (2018). Student Perception of Science as Influenced by Spark Science Learning System (SSLS). *Acta Didactica Napocensia*, 11(1), 87-99. DOI: 10.24193/adn.11.1.7.

view and find science as an enjoyable subject; thus, promoting student motivation. Results of the present research could also inform and encourage teachers to maximize the use of the SPARK in their lessons.

2. The Related Literature

Curriculum Change in the Philippines

According to the DepEd K to 12 Curriculum Guide (2013) the science education aims to develop scientific literacy among learners that will prepare them to become informed and be participative citizens who are able to make sound judgments on matters regarding the applications of scientific knowledge that may have social, health, or environmental impacts. The science curriculum recognizes the place of science and technology in everyday human affairs. It integrates science and technology in the social, economic, personal and ethical aspects of life. Further, one of the aims of the new K12 curriculum is to prepare students to become globally competitive individuals and attain the optimum scientific and technological literacy.

The science curriculum promotes a strong link between science and technology including indigenous technology; thus, preserving our country's cultural heritage. The K to 12 science curriculum will provide learners with a repertoire of competencies important in the world of work and in a knowledge-based society. It envisions the development of scientifically, technologically, and environmentally literate and productive members of society who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators.

As a whole, the K to 12 Science Curriculum is learner-centered and inquiry-based, emphasizing the use of evidence in constructing explanations. Concepts and skills in life sciences, physics, chemistry, and earth sciences are presented with increasing levels of complexity from one grade level to another in spiral progression, thus paving the way to a deeper understanding of core concepts. The integration across science topics and other disciplines will lead to a meaningful understanding of concepts and its application to real-life situations primarily aims to help students understand scientific knowledge and to develop the ability of the scientific inquiry skills. Feedback on the implementation of this newly adopted curriculum may take time from the period of its implementation because it will take two more years to assess the performance level of pioneer students in National Achievement Test under the newly enhanced science curriculum.

Student Perception of Science and their Performance in Class

The main role of perception in learning is to speed up the learning process and recall. Perception involves the use of identification and sensory information of a subject. Exposure to stimulus develops the interest and conscious knowledge of a person which enables better understanding and learning of the person about a specific subject (Kumar & Sampath, 2010).

Some students perceive that their teachers' instructional practices are oriented towards helping them learn but lack of inquiry-oriented activities and support or encouragement for self-directed and effortful learning (Bernardo, et.al, 2008). Without positive attitudes and perceptions, students have little chance of learning proficiently (Marzano, 2006). Learners' perception in science in general plays an important role to learners' achievement. The students' perception of learning is correlated is much higher with student ratings of instruction and did significant gain in their pre-and posttest scores (Centra & Gaubatz, 2005). Moreover, the learners' negative perception in science can be a hindrance in uplifting the interest of students in learning science (Hancer & Tuzemen 2008; Valdez, 2005; Yakar, 2005 & Salgut, 2007). If students develop or possess a better perception towards the subject, they may always look forward to learn more about the subject (Fonseco & Conboy, 2006; Aurentz, Kerns & Shibley, 2011; Centra & Gaubatz, 2005).

Researchers in the developed countries like the United States have focused on students' perceptions of science classes to try to understand some of the problems in the science educational system in their countries (Bernardo, et.al, 2008). Educators must prepare for a technology-rich future and keep up

with change by adopting effective strategies that infuse lessons with appropriate technologies (Valdez, 2005).

Kardash and Wallace (2001) made an instrument to assess the perceptions of students and obtain quantitative data on student perceptions. Their study revealed perceptions related to the problems of teaching in science classes (1) pedagogical strategies, (2) faculty interest in teaching, (3) student interest and perceived competence in science, (4) passive learning, (5) grades as feedback, and (6) laboratory experiences. Women differed significantly from men on the pedagogical strategies, passive learning, grades as feedback, and laboratory experiences factors. Correlational analyses and evidence from distinct groups supported the survey's construct validity. Students reported room for improvement of the science faculty's pedagogical practices. From the students' perspective, how information is taught appears to be the concern to what knowledge is being learned (Psych Info Database Record, 2012).

Bevins and Brodie (2005) conducted a study in England on secondary school students' perceptions of science and engineering. They found out that students do not recognize the specific identities and importance of science regarding its role in society as much as it does with politics. Students suggested that they would benefit if teachers are able to utilize their expertise in the classroom at a time where the experts' particular specialist knowledge would greatly enhance the concepts being taught: students' perceptions towards classroom science. Responses from interviews indicate that students view physics as a difficult and complex subject. The students also suggest that topics such as *forces* have little relevance to their life experiences. School-based educational experiences have a strong influence on students' decision making and career choices. Students perceive physics as 'too hard' and not relevant to them and it is unlikely they will consider further study and career options related to this subject. Biology, on the other hand, is viewed as 'easier' and 'more meaningful'. Students suggest that the application of concepts from biology is transparent and recognizable to them in everyday situations while physics and chemistry have few immediate linkages with their everyday lives. It highlights students' apparent interest in science but lacks enthusiasm for school science education that pays little or no attention to science related issues that students encounter throughout their daily lives. Furthermore, participating students highlight the impact of restricted involvement in practical/hands on sessions in classroom science. The science curriculum is heavily content loaded which reduces teachers' opportunities for engaging students in practical sessions.

In the Philippines, Bernardo, et.al (2008) conducted a study which was a modified version of The Perception of Science Classes Survey by Kardash and Wallace (2001) entitled "*Students' Perceptions of Science Classes in the Philippines (PSCS)*" and surveyed 7,885 grade school and high school students in different provinces in the Philippines regarding their perceptions of their science classes. They developed a survey questionnaire based on the PSCS to study perceptions of Filipino students regarding their science classes. The results suggest that students perceive that their teachers' instructional practices are oriented towards helping them learn but that these practices do not involve enough of inquiry-oriented activities and do not provide enough support or encouragement for self-directed and effortful learning.

Auditor and Roleda (2014), recently conducted a study on the impact of WebQuest on students' critical thinking, performance and perception in basic Physics. Researchers' study determined the relationship between students' content-knowledge acquisition and perception. They employed both descriptive and inferential data analysis procedures. On students' perceptions, statistical analysis showed that students responded positively on the use of Web Quest model in terms of collaboration, creativity, motivation, and knowledge enhancement but were not in time management. They found out there was negligible correlation between students' academic performance and perceptions. Generally, they found out that students viewed Web Quest favorably irrespective of their ability to learn and it suggests that WebQuest model can be a useful tool for student learning.

Integration of computer assisted instruction in science

It is well-established by researches that integrating technology into the curriculum and instruction will bring about significant student achievement and deep understanding of concepts (Clark, 2010;

Morales, 2014; Auditor & Roleda, 2014). However, technology has to be integrated meaningfully into the curriculum and instruction for probable positive impact on student learning and achievement (Clark, 2010). Meaningful integration of technology is the process of matching the most effective tool with the most effective pedagogy to achieve the learning goals of a particular lesson. Each tool brings different opportunities to the learning environment and involves a different set of skills on the part of teachers and students. Further, each tool can play a unique role in the learning process when used at the appropriate time, under the most suitable learning conditions. Therefore, it is simply the degree to which a particular technology's capabilities are matched with the expected learning outcomes and supported by fitting pedagogy that will determine the impact that technology has on learning and achievement (Clark, 2010).

According to Hamilton (2007), integration is an instructional choice that generally includes collaboration and deliberate planning and always requires a classroom teacher's participation. It cannot be legislated through curriculum guides nor will it happen spontaneously. Integration of technology in the classroom may be a vision of an administrator, a teacher, or a specialist needs to model, encourage, and enable integration; however among those with capabilities to make integration of technology happen, only a classroom teacher can make integration successfully happen in the classroom.

Meaningful technology integration touches ground on motivation and appropriate use of tools to match the learners and pedagogy at hand. The information provided by this research is of value to science teachers working on similar objectives. This also allows science teachers to explore and improve their motivation techniques which may later lead to a deep conceptual understanding of the subject matter (Morales, 2014).

Conceptual Framework

Upon the review of the different literatures, a conceptual framework has been created and is shown in Figure 1 below.

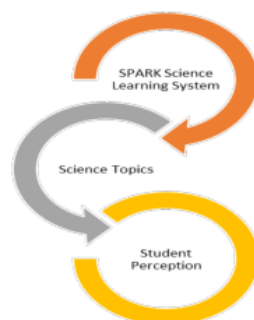


Figure 1. *Conceptual Framework*

The conceptual framework of the present research as seen in Figure 1 shows the three constructs involved in the study. The SPARK Science Learning System has been utilized in teaching certain science concepts and its effect on student perception towards science was determined. As shown in Figure 1, the conceptual framework attempted to explore whether the use of SPARK Science Learning System to perform several experiments could back up the teacher in uplifting the learners' perception in science. This is to find out if the usage of this innovative tool in the selected science topics from the newly adopted K to 12 Science Curriculum could enhance learners' perception in science. The different literatures unfolded that most of the learners have a negative perception in science. The students considered their negative perception were because of the teachers' way of conveying the science lessons, the teachers' practices in the classrooms and the mastery of the subject matter. This study has addressed those present conflicts in science learning.

3. Research Questions

This research aims to find out if the utilization of SSLS to Science Classes has a significant effect on the learners' perception in science. Specifically, this research aims to answer the following questions:

1. Is there a significant difference between the pre-test and post-test means of the students exposed to SSLS and the conventional method in their perception in science?
2. Is there a significant difference between the post-test means of the students exposed to SSLS and the conventional method of their perception in science?

4. Methodologies

Respondents

The respondents of this study are the 87 learners of Andres Bonifacio Integrated School in the Division of Mandaluyong City. The experimental processes were implemented in two sections out of ten Grade-7 sections of the said school in the School Year 2014-2015.

The SSLS groups are the 44 learners who received the treatment. The treatment was the utilization of SPARK Science Learning System device and sensors on science experiments suggested in the K to 12 science modules. On the other hand, the conventional groups were composed of 43 heterogeneous respondents. They were called the conventional group since they were the learners who had a regular learning instruction which was based on the K to 12 learning modules.

Setting of the Locale

This research utilized a quasi-experimental pretest posttest design. The researcher used the topics in the 1st quarter topics in Grade 7. The topics were science investigative processes in the diversity of materials in the environment. The researcher mainly followed the lessons and materials as suggested in the prescribed module of the Grade-7 Enhance Science Curriculum. The instructional processes were implemented for six weeks wherein the teacher-researcher consistently followed the prescribed allotted time for each topic. The topics and the objectives were paralleled in the K to 12 Curriculum in both groups.

Researcher used two SPARK science learning system and two different passport sensors which were temperature and pH sensors. These sensors were part of Chemistry packages. Spark lab automatically recorded the numerical values of the time, temperature and pH levels during the experiments. The allotted time indicated in the SSLS's guidelines, each readymade activity needed to have 150 minutes which is equivalent to 3 days contact with the learners. K-12 curriculum requires 50-minute period in a day. If the researcher would follow the time in the guidelines of the SSLS, all the lessons in the K-12 curriculum allotted in the 1st grading would not be enough, aside from that, some materials in the laboratory activities were not found in the science laboratory of the school. Readymade activities in the SPARK labs of SSLS were not suited in the 1st Grading lessons of the K-12 Enhance basic curriculum. Thus, the researcher prepared simplified modules for the SSLS group who used the SSLS device and SSLS passport sensors. The principal, the head of the science department and the master teachers were not able to observe the classes. Instead, a weekly checking of lesson plan was made by the head teacher and the assistant to the principal.

Extraneous variables which had affected this study were the absences of the learners, suspension of classes on the 2nd week of the conduct of the study due to typhoon Glenda, weak foundation of their science concepts which were beyond the control of the researcher. Student profiles were not taken prior to the conduct of the study. Students who were re-takers of Science-7 were not a part of respondents.

In terms of the instruction, SSLS group was instructed during the experiments with SPARK science learning system, passport sensors and the other materials suggested in the K-12 Curriculum while the conventional group made use of all the materials listed in the module. The researcher prepared a

modified module for the SSLS but this adapted the K-12 modules. The only different between the two groups was that the SSLS group had SSLS software and SSLS passport sensors during their experiment whereas the conventional group had none. Conventional group needed to record the result manually while the SSLS group just read the digital data from the SSLS.

After six weeks of instructions with the two classes, a post-test was administered to both groups. Forty three students took the post test in the control group while there were forty four students for the experimental group or a total of eighty seven respondents answered the post test in the survey of science perception. Pre-test and Post test results were gathered from the respondents to determine the learners' perception towards Science.

Instruments

To determine the perception of students towards learning science, a survey using a questionnaire was administered to the students. The instrument, iKnow My Class Survey, was designed as a formative assessment tool for teachers, giving voice to students' perceptions of various aspects of their individual classes and themselves (Bundick, 2011). The scale of validation of the iKnow My Class Survey used Cronbach's alpha statistics with a reliability test 0.70.

The research instrument made use of a Likert scale to assess the student's agreement or disagreement with the statement to find out the students perception in science. The choices of the respondents range from 1-5 where 5 shows the respondent strongly agrees and 1 if respondent strongly disagree for positive statement, while it is reversely coded for the negative statements.

The choices of the respondents in the survey questionnaire have corresponding scores. Positive and negative statements in the choices were scored 5-1 respectively. The ratings of the students' responses in perception questions were computed to determine the over-all perception of the students towards science. Below are the arbitrary points to be used in interpreting the over-all rating of learners' perception (Soliven, 2004).

Rating	Perception Level
4.2-5	Very Positive
3.5- 4.1	Positive
2.4-3.4	Fairly Positive
1.6-2.3	Negative
1-1.59	Very Negative

5. Results

Statistical treatment assisted the researcher in finding out whether significant difference exists between the pre-test mean and posttest means on the perception of the control and experimental groups. The researcher employed independent sample mean t-test to compare the posttest of the SSLS group and the conventional group while paired samples mean t-test was used to compare their pretest and posttest mean scores.

Initially, the learners' test scores in their pre-test had undergone test of normality to find out whether they are normally distributed to determine what statistical treatment should be employed. It employed Shapiro-Wilk Test for normality at 0.05 level of significance.

Table 1: *Shapiro Wilk Test of Normality*

Variable	Group	Test	p-value	Interpretation
Science Perception	Conventional Group	Pretest	0.263	Normal
	SLSS Group	Pretest	0.086	Normal

Table 1 shows that the normality for the distribution of the data varies. Shapiro Wilk-test analysis revealed that the pre-test scores of both control and experimental groups in their perception in science and integrated science process skills are normally distributed.

The primary goal of this study is to find out the effect of usage of SPARK Science Learning System on students' perception. To determine if there is a significant gain in learners' perception in Science, statistical comparison of the pre-test and post-test of the participants exposed to SSLS and those who were under the conventional method on their perception in Science through paired sample t-test is presented in the table below.

Table 2: *T-test comparison in the Pre-test and Posttest Scores in Science Perception*

Group	Test	N	Mean	t-test	p-value	Interpretation
Conventional	Pre-Test	43	204	-2.43	0.019	Significant
	Posttest	43	214.05			
SSLS	Pre-Test	44	208.16	-3.53	0.001	Significant
	Posttest	44	221.25			

Table 2 shows that the participants in the SSLS group had a higher perception in their posttest as compared to the pre-test after the utilization of the SPARK Science learning System. The difference in the pre-test mean and the posttest mean was statistically significant with a p-value less than 0.05 (p-value=0.001<0.05). Similarly, participants in the conventional group had a better perception too in the posttest as compared to the pre-test after the used of the prescribed Grade-7 modules in their perception in Science. The difference in the pre-test mean and the post-test mean was statistically significant with a p-value of less than 0.05 (p-value = 0.019 < 0.05). The SSLS group that utilized SPARK Science Learning System has higher mean difference in their perception in science than the conventional group. The pre-test and posttest mean difference of the control group is 10.047 while experimental group is 13.09 (Md=10.07<13.09). However, results show significant gains in both groups in the students' perception in Science. This implies that the utilization of both SPARK Science Learning System and the K-12 Science modules in teaching Science Investigative Processes in the diversity of materials in the environment could be an avenue in improving learners' perception in Science.

The present result seems to respond on the study conducted by Bernardo, et.al (2008) whom suggested that students perceive that their teachers' instructional practices are oriented towards helping them learn but that these practices do not involve enough of inquiry-oriented activities and do not provide enough support or encouragement for self-directed and effortful learning. Utilization of SPARK Science Learning System as well as the modules prescribed in the K-12 Curriculum were bunches of activities to encourage learners to perform different tasks and hold on the idea of learning by doing.

The rating of the students' responses in perception questions was computed to determine the over-all weighted mean in the learners' perception in science. Arbitrary points were used in interpreting or determining the level of perception of as shown in the table below.

Table 3: *Pre-test and posttest over-all mean score of the control and the experimental groups and interpretation of level of the learners' perception*

Group	Test	Over-All Weighted Mean	Level of Perception
Control	Pre-Test	4.07	Positive
	Post-Test	4.28	Very Positive
SSLS	Pre-Test	4.16	Positive
	Post-Test	4.4	Very Positive

Table 3 shows the comparison of the participants pre-test over-all weighted and posttest over-all weighted means on the learners' perception in science. The result shows that there is an increase in the perception level in both groups. The pre-test over-all weighted mean in both groups show that the learners have positive perception prior to the instructional process. The posttest over-all weighted mean indicates that both groups have a very positive level of perception in science. It could be deduced that both groups changed their level of perception in science after implementation of the two

learning pedagogies. This implies that both learning pedagogies have the ability to increase students' level of perception in science. However, it was observed that the SSLS group has a higher weighted mean score than the conventional group.

The result of this study agrees with (Montebon, 2014) that the learners have positive perception in the K-12 Science Curriculum. As shown in table 3, the pre-test of the conventional and the experimental group revealed that the participants have positive perception towards the implementation of the K-12 Science Curriculum prior to the implementation of the instruction. Although learners have already manifested a positive perception towards science due to the newly implemented curriculum, the posttest mean score in their perception in science were significantly different. This significant gain made their positive perception become very positive. This change signifies that after the implementation of both learning pedagogies, SSLS group that used SSLS and the conventional group that used the prescribed modules in Science can be avenue to uplift the learners' perception in science.

On the contrary, this result disagrees with the findings of Jenkins and Pell (2006) from the ROSE project on the science perspective of students in England. These are largely concurrent with those of school students from industrialized nations globally. Most boys but, in particular, girls prefer other subjects to science. Furthermore, the study of Bevins and Brodie (2005), a study in England on secondary school students' perceptions of science and engineering and found out that students do not recognize the specific identities and importance of science regarding their role in society as much as they do with politics. Seymour and Hewitte (1997) revealed that many informative perceptions of students, such as the perception that science teachers dislike their students and do not have the motivation to teach effectively. The students interviewed also perceived many features of ineffective teaching in science such as the lack of fit between the materials used in class and the tests and assignments, the use of grading practices that do not reflect actual student learning, an overemphasis on memorization instead of conceptual understanding and establishing conceptual connections, among many others. Their study of students' perception revealed notions of good teaching in science classes, such as encouraging discussion, and valuing the sense of discovering things together, and respecting students

Negative perception in science among learners in the previous studies was observed in different countries. Notice that these results could have been different in terms of perspectives of participants depending on the setting. The adaption of the K-12 Science curriculum might have been a factor that changed the learners' perception in science.

To explicitly detail whether specific component in learners' perception in science has truly improved, the pre-test means and posttest means comparison of the eight components of the learners' perception in science of the control group is shown in Table 4 below.

Table 4. *T-test Comparison of the Eight Components in Science Perception of the Conventional group*

Skill	Pre-test	Posttest	t-value	p-value	Interpretation
Meaningful Engagement	2.52	24.1	-1.3	0.200	not significant
Relevance	3.03	31.14	-1.18	0.24	not significant
Relationship	37.07	39.35	-2.54	0.015	significant
Class Efficacy	48.98	51.91	-1.52	0.076	not significant
Cooperative Learning Environment	20.02	21.4	-2.23	0.031	significant
Critical Thinking	36.19	39.6	-3.27	0.002	significant
Positive Pedagogy	4.25	4.23	0.113	0.898	not significant
Discipline Problem	1.84	2.37	-1.9	0.064	not significant

Table 4 shows that after the implementation of the instructional processes, the control group increased the critical thinking and class efficacy of science perception respectively. Most of the eight factors in science perception had increased after the implementation of the instructional process. T-test revealed that only the three components in science perception had increased significantly. The differences in

the pre-test mean and the posttest means of three components were statistically significant. These are as follows: in relationship with a p-value of 0.015 less than 0.05 ($p\text{-value}=0.015<0.05$), in cooperative learning environment, the p-value of 0.031 less than 0.05 ($p\text{-value}=0.031<0.05$) and critical thinking with the p-value of 0.002 less than 0.05 ($p\text{-value}=0.002<0.005$) is also less than and critical thinking. This implies that usage of the prescribed modules in Science can uplift such factors. These three components are important factors in learning science. Relationship is the building up a positive relationship between the learners and the teachers brings a good camaraderie which can result to positive learning outcome. Positive relationship among learners could lead to cooperative learning of the students. Learner's perception in critical thinking improved too, thus this implies that the learners, developed their science-inquiry skill, which is the aim of the SSLS.

However, it could be observed that after the posttest, the engagement of the learners in the conventional group has a decrease of 1.1. The occurrence may have happened because certain learners were absent and there were many tasks to do during the instructional process. When they came back for school, they had a lot of activities to catch up. They were also tasked to perform several experiments which they are not used to prior to the instructional process. In an interview, a student from the conventional group honestly replied, "[w]e did not usually perform science experiments in the past. We experienced difficulty and confusion in the different tasks but we believed, experiments are needed in science classes because these will help us learn more." Such difficulty of students agrees with de Frondeville (2009) and Weiss and Pasley (2004) ideas that student motivation and adaptability towards technology in the classroom takes time and is affected by different factors: exposure time to the technology, engagability of activities provided, and the competence of students for the technology.

To explicitly detail the specific components if learners' perception in science has truly improved, the pre-test means and posttest means comparison eight of the components of the SSLS is shown in the table 5.

Table 5: *T-test Comparison of the Eight Components of Science Perception of the Pre-test and Posttest of the SSLS Group*

Skill	Pre-Test	Post Test	t-test	P-value	Interpretation
Meaningful Engagement	25.2	25.5	-2.31	0.822	not significant
Relevance	29.57	31.23	-2.39	0.021	significant
Relationship	37.97	40.86	-3.39	.002	significant
Class Efficacy	48.98	51.91	-3.55	.001	significant
Cooperative Learning Environment	20.02	21.4	-1.25	0.218	not significant
Critical Thinking	36.19	39.6	-3.27	0.002	significant
Positive Pedagogy	4.25	4.23	-0.91	0.368	not significant
Discipline Problem	1.84	2.37	-1.86	0.07	not significant

Table 6 shows that after the post test, the experimental group obtained the highest increment in class efficacy and critical thinking in science perception. The comparison of posttest and pre-test of the SSLS group revealed significant gain in the four components in learners' perception in science which are relevance, ($p\text{-value}=0.021<0.05$) relationship ($p\text{-value}=0.002<0.05$), class efficacy ($p\text{-value}=0.001<0.05$) and critical thinking ($p\text{-value}=0.002<0.05$). This result implies that usage of SSLS in science class could further improve such components. This shows that SPARK has the ability to improve the following: teachers and learners' application of the content and information how this science content applies to the student's everyday lives, the trust and the mutual respect between the students and the teachers, the assurance of the teacher that the students are able to be themselves, ease in making inquiries about the content hesitation when asking for support in their own learning.

Comparison of Post-tests Scores in Perception

Problem number 2 aimed to find out if there is a significant difference between the post-test means of the students exposed to SSLS with those who were under the conventional method in their science

perception. An independent sample t-test was employed to determine if there is a significant difference in learners' perception in science. The statistical comparison of post-test of the participants exposed to SSLS and those who were under the conventional method on their perception in science is presented in the table below.

Table 6: *T-test comparison between the post-test mean scores of the control and the experimental groups on their Science Perception*

Variable	Group	N	Mean	Mean Difference	t-value	p-value	Interpretation
Science Perception	Conventional	43	214.05	7.2	-2.22	0.029	Significant
	SSLS	44	221.25				

Table 7 shows the over-all post-test mean scores of the two independent samples. The conventional group has a post-test mean score of 214.05 while the SSLS group has a mean score of 221.25. These mean scores have a mean difference of 7.2 which gain a p-value of 0.029 less than 0.05 level of significance ($p\text{-value}=0.029<0.05$). Such difference suggested that there is a significant difference on the post-test mean scores in the science perception between the conventional and the SSLS groups. This implies that the integration of SSLS has a positive effect on the learners' science perception better than the conventional group. This study also revealed that after the implementation of the experimental process, the group which received the integration of SSLS had higher science perception than the control group which had the traditional method of teaching under the K-12 curriculum. This suggests that SSLS can elevate the perception of learners in science.

Present study revealed that utilization of SPARK Science Learning System improved learners' perception in science. Previous studies also disclosed that perception and achievement are correlated, that supports why ISPS of the learners improved as well.

This study agrees on the study of Kumar and Sampath (2010), the main role of perception in learning is to speed up the learning process and recall. Exposure to stimulus develops the interest and conscious knowledge of a person which enables better understanding and learning of the person about a specific subject. This denotes that as the perception of learners improve; the more motivated they will be in learning the subject thus, they will perform better as well.

To explicitly detail which specific component of the learners' perception in science has significant difference between the posttest means of the control and the SSLS groups, statistical comparison of the posttest means of the participants on their perception in science through independent sample means t-test was made as presented in the table below.

Table 7. *Posttest Comparison of the Component of the Conventional and SSLS Groups in Science Perception*

Skill	Conventional	SSLS	t-value	p-value	Interpretation
Meaningful Engagement	24.1	25.5	-2.00	0.049	significant
Relevance	31.14	31.23	-0.143	0.866	not significant
Relationship	39.35	40.86	-1.95	0.037	significant
Class Efficacy	51.91	54.09	-1.43	0.158	not significant
Cooperative Learning Environment	21.4	21.68	0.472	0.638	not significant
Critical Thinking	39.6	40.68	-1.28	0.206	not significant
Positive Pedagogy	4.23	4.18	0.32	0.749	not significant
Discipline Problem	2.37	2.86	-1.57	0.12	not significant

Table 8 shows the comparison of the mean scores and their mean differences between the conventional and the SSLS groups. It statistically reveals that utilization of SSLS has improved in terms of meaningful engagement with a p-value of 0.049 less than 0.05 level of significance ($p\text{-value}=0.049<0.05$) and relationship with a p-value of 0.037 less than 0.05 level of significance ($p\text{-value}=0.037<0.05$). This reveals that most of the mean scores of the experimental group were higher than the control group. Class efficacy has the greatest mean difference though difference was not

significant. Since the difference on the over-all posttest mean scores of the control and the experimental group were statistically significant, it could imply that, utilization of SSLS has a better effect on the over-all science perception of the learners in the experimental group. In the eight components, it specifically unfolded that the SSLS group has a better improvement in learners' engagement and relationship.

This implies that SSLS improved the engagement of learners to learn the concepts through experiments and built up a better student-student and teacher-student relationships.

6. Conclusions

The present research investigates primarily the perception of students of their science lessons when technology in the form of SSLS was used in their classes. The pre and post test scores of students' responses on the iKnow My Class Survey revealed a significant difference ($t = -2.11$ at 0.0 sig.). It means that students' perceptions of their classes were positive upon using SSLS in their classes.

Results of the study agrees with the findings of different researchers (Valdez, 2005; Chingos & Whitehurst, 2012; Aurentz, Kerns & Shibley, 2011; Morales, 2014). According to Valdez (2005), technology based learning tool is needed to achieve statistically significant effects. Thus, the use of SSLS to science investigative lessons support that educators must adapt to the modernizing education setting by infusing technology in their classroom strategies. The results of this study also agree with Chingos and Whitehurst (2012) whom revealed that there was strong evidence that the choice of instructional materials has large effects on student learning. Contrary to common practice of educational institutions to wrongly or blindly choose instructional materials without evaluation most of the time, results of the present research affirms the schools' effort to properly evaluate the impact of SSLS on the learners performances through this study.

To assist students as they learn science under the K to 12 program is the underpinning principle of the researchers upon the conduct of this study. Consequently, research results revealed that SSLS improved their view of their science classes; Aurentz, Kerns and Shibley (2011) said that inclusion of modern instrumentation indicated a positive change in students' perception in scientific ideas.

Bernardo (2004) suggest that classrooms in the Philippines should anchor more on the constructivist philosophy. In the present research, constructivism has been an evident philosophy that have been observed in the classroom as student learn science with the use of SSLS; for SSLS may allowed learners to connect lessons with prior knowledge and investigate new concepts through hands on experiences that lead them to develop new knowledge.

Lastly, the results of the research affirms that of Morales (2014): SPARK Science Learning System is an effective technology to be used in science classes for it enables students to improve their innovation skills, develop their creativity, use critical thinking, enhance their communication skills, and collaborate with their peers and teacher. That said, the present research posits that SPARK Science Learning System can help assist the K to 12 program to achieve its goals of developing a scientific literate citizen.

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RESEARCH ARTICLE 16

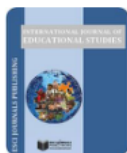
Integrating Graphic Organizers in Facilitating Learning Chemistry

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International Journal of Educational Studies, 1(1), 1–8

Original publication: 2014

Int. J. Educ. Stud. 01 (01) 2014. 01-08



Available Online at ESci Journals

International Journal of Educational Studies

ISSN: 2312-458X (Online), 2312-4598 (Print)

<http://www.escijournals.net/IJES>

INTEGRATING GRAPHIC ORGANIZERS IN FACILITATING LEARNING CHEMISTRY

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ABSTRACT

The study was intended to facilitate learning chemistry through the integration of graphic organizers (GOs). This study specifically determined the attitude toward chemistry and achievement of two groups of students under study. The study indicated that there is a significant difference between attitude toward chemistry of students in the experimental group before and after the experiment. The result of students' perception about GO, as teaching strategy and approach to teaching chemistry, indicated the rationale in this undertaking. All presentations used by the teacher in the class incorporating graphic organizers in identified formats such web diagram, flowchart-concept map, Venn diagram and pictorial graphics obtained a good and very good perception. Performance, on the other hand, indicated ultimate measure of GO's effectiveness in facilitating learning. This analysis implied that the experimental group performed significantly better than their counterparts in the control group with adjusted means scores of 47.45 and 39.11, respectively. Facilitating learning chemistry can be made through integrating graphic organizers. GO-based presentation solicited and indicated positive attitude from the students. Hence, the use of graphic organizers effect changes in behavioral dimensions of learning content for the better. GOs as conditioners can make students perform well and may seem to improve their attitude toward learning. GO is apparently indicating success as critical index of learning. It is recommended that GO be used by teachers to improve attitude and achievement of students.

Keywords: Facilitating learning, graphic organizers, visual learning, attitude toward chemistry, student performance.

INTRODUCTION

Learning to think and thinking to learn are two imperative skills essential to knowledge economy. One way to substantiate this is to make curriculum more facilitative to both students and teachers. According to Hall and Strangman (2002), integrating graphic organizers can be supportive of teacher's teaching and student learning. Graphic organizers (GOs) are visual displays that make information easier to understand and learn (Dye, 2000). It provides holistic representation of facts and concepts and their relationships within an organized frame. GOs have been applied across a range of curriculum subject areas and research-based applications have demonstrated their classroom utilization in the sciences, social studies, language arts, and mathematics. Operations such as

mapping cause and effect, note taking, comparing and contrasting concepts, organizing problems and solutions, and relating information to main ideas or themes can be beneficial to many subject areas (Hall & Strangman, 2002). Nowadays, the GO appears to gain popularity among modern schools as it is used as a favorite teaching approach and as an accepted strategy in the classroom, as well. GO is the umbrella term for the various types of visual organizers and advance organizers. GOs exist in a variety of forms and are sometimes referred to as concept maps, story maps, advance diagrams, semantic maps, or concept diagrams. The acceptance and adoption of GOs to classroom across content areas and even across levels is an extract to the recommendation of numerous educational and cognitive psychology researchers showing that creating graphic representations to the students and by the students can enhance understanding of the content (Horton, Lovitt, and Bergerud, 1995).

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Chemistry is regarded 'abstract' or difficult science to some and if not attended properly by the teacher, this may create misconceptions as far as students' processing of content is concerned. Researcher's experience with the students various academic programs concretize this condition. Students really find difficulty in understanding content information, especially if the lesson and its presentation seem to be insufficient in practical substance, plus the fact that no innovation has been conceptualized by the teacher to invite students in the meaningful learning. The experience of the researcher, who is the teacher, being involved in tertiary instruction and being with students who find difficulty assimilating and processing science information, teacher should really invest employing innovative methodology appropriate to students' instructional needs. In light of all these, Chemistry teachers must consider instructional tools such as GOs

which according to Jonassen (1998) are "*generalizable*" tools that can facilitate cognitive processing and communicate the logical structure of the instructional material (Jonassen, 1993).

Facilitating learning characterizes important element of the educative process, the learners – who are the focal point of teaching and learning. Through this emanates the constant consideration for the learner to the holistic perspective of education; be it in curriculum and instruction, in areas of assessment and evaluation, or in pedagogical practices. As this undertaking is revolving in the concept that chemistry teaching has to understand attitude of students and create environment so as to enhance performance of these students in the class, the use of teacher-made presentation can significantly elevate the dynamic process of chemistry learning as associated by most researchers about graphic organizers.

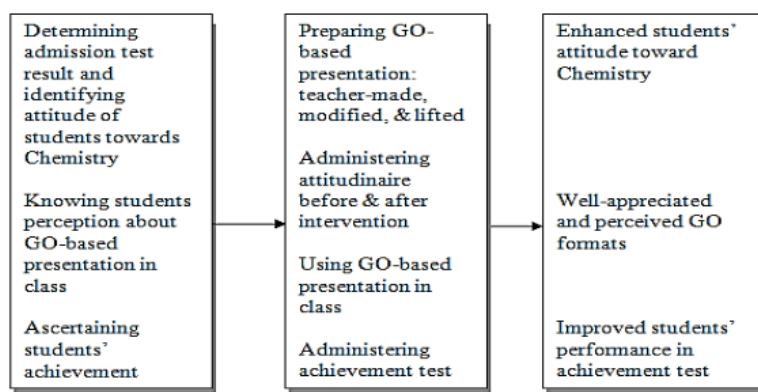


Figure 1. Research Paradigm of the Study

Figure 1 below specifies various variables of the study.

As indicated in the figure, the first tier presented research inputs, which are the variables of this undertaking: admission test result and attitude towards chemistry of the students, perception of the student in the use of graphic organizers, and academic performance or achievement of the students. The second tier deals about the critical processes entail in the research including (1) preparation of GO-based presentation, (2) administration of attitudinaire, (3) utilization of GO-based presentation in the class, and (4) administration of achievement test. The third tier of the paradigm present three (3) response variables which eventually devised rationale in the grounds being tested about graphic organizers and its powerful qualities as

visual organizers. These are (1) enhancement of attitude toward Chemistry, (2) good perception about GO, and (3) improvement of academic performance (achievement) of students.

This paper attempted to test other graphic organizing tools beside concept map. As graphic organizer has been noted powerful visual tool then this undertaking gravitates in that construct to test the effect of GO-based presentation in learning chemistry in enhancing attitude and academic achievement of students.

The study was intended to facilitate learning environment with integration of graphic organizers (GOs) as learning tool on selected topics in Chemistry.

Specifically, it attempted to answer the following problems:

- Is there a significant difference in the attitude of students in the (a) experimental group exposed to GOs and (b) control group exposed to lecture-demonstration method before and after intervention?
- What is the perception of student exposed to lessons integrating graphic organizers in learning chemistry?
- How does the achievement test in chemistry of students in the experimental group differ from the control group?

This study focused in facilitating learning environment with integration of graphic organizers (GOs) as learning tool in selected topics in Chemistry. The GOs used in this study are clustered into web and Venn diagrams, flowchart, and pictorial form. Topics are chosen based on the content requirements as appeared in General Chemistry Course Syllabus and Information. The researcher, who is also the teacher of the class, gathered the necessary data and information in developing the lessons which was based in the course syllabus. These GOs were constructed, modified, or lifted from the internet and other materials such as books in preparation for actual classes. These GOs undergo validation by chemistry teachers and subject matter specialist/experts.

Two intact classes are involved in the study namely; the experimental and control groups. There were 68 participants in this study. Admission test result of these students is used as basis for the selection. The intact classes are heterogeneous.

Significant to the study is the preparation and consideration of the research instruments. For this undertaking, three (3) research instruments are used namely; (1) a 15-item attitudinnaire, (2) perception questionnaire, and (3) teacher-made test. The 15-item attitudinnaire is patterned and taken from a validated 30-item Views about Science Survey (VASS). VASS probes student views in both scientific (structure and

validity of scientific knowledge, and scientific methodology) and cognitive dimensions (learnability of science, reflective thinking, and personal relevance of science). This is however refined to conform to the requisite items of the study which included only the cognitive dimension of learning. The advisers validated the modified 15-item attitude questionnaire. Another instrument is the perception questionnaire. It is a researcher-developed questionnaire containing and outlining 20 GO-based presentations used in the class. The third questionnaire is the multiple-choice type of test consisting of 60 items and which covers related topics in chemistry to assess students' academic achievement. It is a teacher-constructed test whose reliability was determined through Kuder-Richardson formula 20.

This study was further delimited to these aspects which include the following: (1) mental ability of the students was not considered since class section is determined by first come first served enrolment system; (2) strict validation procedures to be undertaken in the instruments were not done; (3) contamination of information is one feature that the researcher may not control since two intact classes are within the same school. However, a measure to at least lessen its effect has been indicated.

METHODS

Research Design: This investigation opted both the descriptive and the quasi-experimental research designs. The descriptive method was used in depicting students' attitude towards chemistry, perception about GO and academic performance. This was also applied in presenting the results of the study. Contrastingly, the quasi-experimental method is employed to establish cause-and-effect relationship between variables of the study. According to Redfield, Sivin-Kachala & Schneiderman (2003), quasi-experimental designs must include at least one comparison group, they may or may not include a control group.

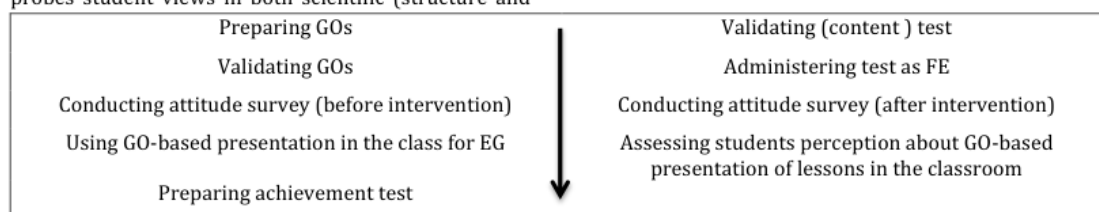


Figure 2 indicates the research process that this study has undergone.

Research Instrument. Attitudinaire, perception questionnaire, and achievement test were utilized to gather pertinent data for the research. These instruments are made suitable in drawing together the requisite information needed for this research.

Participants of the Study. Participants of this research

Table 1. Students' college admission test (CAT) result.

Group	Mean	Mean Difference	t-value
Control	69.85	3.32	2.73*
Experimental	66.53		

* $p < 0.05$.

The t -value is insignificant at the 0.05 level, implying that if the admission test can be an indicator of academic standing and mental ability, the two groups are not equal. Thus, students in the control group have better mean admission test scores, 69.85, than those in the experimental group, 66.53. This statistical result requires this parameter to be a covariate of achievement.

Data Gathering Procedure. The researcher, who is the teacher, started working with the study in successive phases. Phase 1 entailed preparation of graphic organizer-based presentations. GOs being used in the class refers to as GO collection can either be teacher-made, lifted or modified. Content validity of the materials integrating GOs was done by some teachers and thesis adviser.

Phase 2 was the experimentation phase which involved initially of class orientation and subsequent administration of attitudinaire and implementation of intervention to classes. Before the experiment, the teacher administered the attitudinaire to both group being tested. After subsequent exposure of students to the intervention, the same set of attitudinaire was asked to answer by the students. As significant part of this study, experimental group was asked to answer perception questionnaire after intervention.

Finally, phase 3 was about assessment of student learning through an achievement test. The two intact groups were evaluated through achievement test administered as final examinations of the course.

Data Analysis Procedure: The weighted arithmetic mean was used to describe typical behavior of the students from the attitudinaire instrument used.

The t -test was used to determine significant differences between the mean scores in attitude and achievement of students assessed before and after the experiments.

are freshman students enrolled in the College of Hotel, Restaurant, and Tourism Management (CHRTM). Two intact classes were involved in the study namely; the experimental and control groups. Table 1 below presents data in setting the comparability of two groups of students.

The analysis of covariance (ANCOVA) was also performed to partial-out the effect students' attitude before experiment in comparing the students' attitude after experiment in the experimental and control groups. It is also used in order to analyze achievement test as indicator of change in performance in chemistry with admission test as covariate.

RESULTS AND DISCUSSION

Students' attitude toward chemistry: Initially, the attitude toward chemistry of students in the experimental group is revealed to be fair in most indicators. Such fair regard to science may be derived from high school science program. This however describes students' learnability, reflective thinking, and personal relevance of science as serious, teacher-dependent and is significant in everyday life respectively. Students primarily thought that chemistry is a hard and tough science to deal with and that serious learning is necessary. Teacher dependence is one quality revealed while their reflection about the lessons to learn about is weak. On the other hand, the attitude toward chemistry of students in the control group before the experiment is characterized to be better before intervention indicating more positive attitudes in most dimensions being considered as compared to the experimental group. After the experiment, *i.e.* exposing students to lecture-demonstration method, the same level of positive results in attitude is obtained in most indicators while remain to be agreeable.

Firstly, there is a significant difference between attitude toward chemistry of students in the experimental group before and after the experiment. The computed t -value of 8.51 gives a p -value of less than 0.05. Hence, it can be deduced that the students' attitude toward chemistry in the experimental group differs significantly before and after the experiment. Such indicated change of attitudes

is characterized to be for the better after subsequently subjecting the class to lessons incorporating GOs. Thus, GO as teaching tool indicated effect on the way learning was made. The utilization of GO changed crucial behavior toward learning chemistry. GO makes meaning, and as an advanced organizer, it can make learning meaningful (Ausubel, 1969). Ausubel (1969) further expressed, that in order for "meaningful learning" to occur the individual must have established learning by determining if the information received is meaningful. If this information is meaningful, then the individual will process the information and this will strengthen his/her knowledge. Since positive result toward changing students' attitude is derived then each

Table 2. Mean score difference in attitude toward chemistry of student in the experimental and control groups before and after the experiment.

Group	Period of Experiment	Mean	Mean Difference	Computed <i>t</i>
Experimental	After	4.26	0.85	8.51*
	Before	3.41		
Control	After	4.40	0.57	6.62*
	Before	3.83		

* $p < 0.05$; $t = 2.145$.

Lovitt (1994) however signified that both teacher-directed and student-directed approaches are considered to be best practices when working with appropriate approach based upon the purpose of the lessons and individual needs of the students.

Table 3. ANCOVA Table - Mean difference of Students' attitude toward chemistry before experiment with attitude after experiment as covariate.

Sources	Adjusted Sum of Squares	df	Adjusted Mean Square	F-value
Grouping	0.495	1	0.495	7.336*
Error	4.348	65	0.067	

* $p < 0.05$

Table 3 suggests that there exist significant difference in the attitude toward Chemistry between the two groups, based on the p -value less than 0.05. The attitude mean rating of the experimental group which is 4.26 is higher than the adjusted mean of control group which is 4.07, it can be inferred that students who are exposed to the GOs appear to have indicated more positive attitude than their counterparts in the control group. Hence, graphic organizers are valuable in any activity which requires the use of critical thinking. The use of these tools can generate excitement and enthusiasm toward learning. Therefore, graphic organizers appear to be a beneficial instructional strategy to support students in retaining learned information longer and to

student experienced meaningful learning. From the orientation about chemistry requires serious efforts to be learned, it turned out that chemistry can be viewed as fun and exciting subject. Conclusively, such meaningful learning changed *learnability of science* among students. From this context, it can be deduced that the use of GO is tantamount to strategize. Secondly, determined significant difference is also accounted in the attitude of students in the control group, as computed t -value of 6.62 results to a p -value of less than 0.05. This means that the attitude of the students toward chemistry varies before and after the experiment.

Consequently, to partial out the effect of students' attitude before the experiment, analysis of covariance (ANCOVA) had been applied using attitude after the experiment as covariate.

learn more effectively since behavioral dimensions have been set in place.

Students' perception about GO: With respect to identifying perception of students exposed to lessons integrating graphic organizers, *i.e.* for the experimental group, in learning chemistry, data presented below tabulated the results.

Students' perception is regarded significant in this paper. In this undertaking, it may provide explanation imperative to answering what caused change in the attitude of students in the experimental group after the experiment. There is an indication that graphic organizer-based presentations used in the class are all acceptable as all 20 collections included in the

perception questionnaire obtained a good to very good rating in the ranges set by this research paper which is 3.51-5.00.

As far as web diagrams being utilized in the study are concerned, it appeared that the features of this organizer became students' most favorite GO as the highest composite mean of 4.58 (VG) is derived. Such attribute central to web diagram is that students felt the liberty to express ideas as encourage by the feature of this GO. In addition to this, students expressed vividly the created link of ideas hence it verified the assessment findings about learnability, *i.e.* serious learning to fun and exciting learning.

Another powerful graphic organizer and noted visual organizer-format helpful to the learners is the concept map (or flowchart). The perception about this group of GO is indicated in table 9 and obtained a composite mean of 4.41 (G). During implementation of this intervention, three (3) flowchart-concept maps are rated very good.

The indicator *In chemistry, it is important for me to learn ways to organize information and use it* emphasized the importance of flowcharting-concept mapping as an organizing and learning tool. It can be remembered that initially this statement belong to low mean-scored indicator and raise to rank 2 after exposing students to GO. The result may seem to reflect students' appreciation as they learn ways to organize information which is directed toward reflective thinking. Relatively previous studies linked congruence to the present findings. Houston (1993) has investigated on the effectiveness of concept mapping as an instructional tool and showed that concept mapping has generally positive effects on both students' achievement and attitudes. Johnson (1997) on the other hand, indicated that the effect of concept mapping on the memory

retention and understanding can be explained in the way students were helped to remember and assimilate information (Johnson, 1997).

The ability of concept maps to present information in sequential and in hierarchical forms enable the student to draw correct ideas about and outline of text in his memory, thus, enhanced his ways of content acquisition. In this regards, active learning as well as generating and harnessing of conceptual knowledge become evident to students.

The use of Venn diagram as visual organizer has elevated students' learning of content and crystallizes the way topic has been presented on the perspective of students. It facilitated learning by depicting to the mind the crucial tasks of comparing and drawing the features of similarities and differences about the concept being discussed in the classroom. In overall, research in both educational theory and cognitive psychology tells us that visual learning is among the very best methods for teaching students of all ages how to think and how to learn (Marzano, Pickering, & Pollack, 2001). To reiterate, the comparative theme of GO helped learners to summarize learning, encourage elaboration, organize ideas and concretize abstract information. These, as mentioned, become evident as outcomes such as better content acquisition, and harnessed skills as such processing, analytical, and communication, were manifested. Motivating students can be best done through GO and invite them in meaningful learning.

Students' achievement in chemistry: Achievement as a research output in this undertaking takes a crucial standing. The achievement in chemistry of students in experimental group exposed to graphic organizers and students in the control group exposed to the lecture-discussion method is presented in the succeeding table.

Table 3. Summary of Results of Students' Perception in the Utilization of Graphic Organizers in Chemistry.

Type of graphic organizers	Number of presentations	Composite Mean	Verbal interpretation
Web diagram	2	4.58	Very good (VG)
Flowchart	12	4.41	Good (G)
Venn diagram	2	4.26	Good (G)
Pictorial formats	4	4.34	Good (G)

Table 4. ANCOVA Table – Achievement test in chemistry with admission test as covariate.

Sources	Adjusted Sum of Squares	df	Adjusted Mean Square	F-value
Grouping	0.495	1	0.495	7.336*
Error	4.348	65	0.067	

* $p < 0.05$.

The comparison of students' achievement test results with admission test as the covariate shows significant difference at the 0.05 level of confidence. This analysis implies that the experimental group performed significantly better than their counterparts in the control group with adjusted means scores of 47.45 and 39.11, respectively. This result significantly conformed with previous research and theory about GO. Main points were indicated by Hartman (2000) who mentioned that GOs are useful as a conceptual communicative tool. As GO expounds processing of information, it allows operationalization of learned facts.

Novak and Gowin (1994) research about concept map, had revealed a positive result in students' achievement and thus, it is concluded that learning process had been facilitated. Guastello et al (2000), Ritchie & Volkl, (2000), and Willerman & Mac Harg (1991) focused on the same ground to facilitate learning of science content. From these studies indicated that the use of graphic organizers is an effective way to improve student comprehension and retention.

Integrating graphic organizers tend to elevate students' attitude toward learning chemistry. Katayama & Robinson (2000) used to mentioned that GO engages students in learning, resulting in encoding benefits. In the process, students made evident better learning output indicated by better scores in the achievement test. On this premise, features and themes of GO had served the purpose as the students revealed certain learning outcomes as active content acquisition, processing skills, critical thinking skills, and communication skills. Toward this finding is the ability of students to provide conceptual knowledge or framework for integrating new information and the encouragement of prediction. With respect to other skills, Web diagram allowed student to become spontaneous in expressing their thought, thus communication skills has been harnessed. Critical thinking skills are also developed reflective of students' ability to summarize learning, elaboration, and concretizing abstract information.

Achievement is the ultimate indicator of meaningful learning as far as this paper is concerned. It summarizes the interplay of variables such as student attitude toward learning chemistry and student perception about using GOs in the classroom. The utilization of graphic organizers appear to facilitate learning as

students in experimental group reveal better scores compared to control group as indicated by t-test. It can be noted that this result can be explained by attitude shift brought about by GO.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions. Based on the findings mentioned above, herewith are the conclusions drawn: From that start point of learning chemistry, students' cognitive skills were enhanced. Different learning skills such as processing, critical thinking and communication skills became apparent. Therefore, interventions used by the teacher affect the attitude of the students towards learning chemistry and the use of GO constructed learnability, reflective thinking, as well as personal relevance of science in a way beneficial to the learner. Graphic organizer-based presentation solicited and indicated positive attitude to the students, hence, the use of graphic organizers effect change in behavioral dimensions of learning content for the better.

It is concluded students' perception on the use of GO-based presentation affirms the utilization of GO as pedagogy in facilitating learning. As more skills imperative to learning were exhibited, their perception of doing and learning about was transformed. Textual information (or the content) is advantageously learned with the use of graphics.

RECOMMENDATIONS

Facilitating learning chemistry can be made through integrating graphic organizers. This pedagogical input produces learning output of improving academic achievement of students. GO as effectors can make students perform well as achievement of students is said to be directly proportional to the teachers' translated strategy. GO promotes visual literacy and students are encouraged to create their own organizers reflective of the meaningful learning derived from the classroom. Graphic organizer as visual learning tool establishes meaningful learning. Through this research experience, reflection on pedagogical relationship translated into what the researcher call 'pedagogical equation' has been derived, i.e. "Teaching input is directly proportional to learning output, thus achievement, behavioral encouragement, and among others as desired learning output cannot be manifested without the teacher investing to an appropriate strategy that can be customized to the learner's situation". No amount of input, on the other hand, can create

Int. J. Educ. Stud. 01 (01) 2014. 01-08

meaningful learning if teachers stagnate and will not harness his instructional skills.

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RESEARCH ARTICLE 17

Modelling Metacognition in Science Teaching: A Philippine Context

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SEAMEO Congress 2021

Original publication: 2021



Modelling Metacognition in Science Teaching: A Philippine Context

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ABSTRACT

In this study, metacognition is understood and explored in the context of teaching as framed by Flavell (1979) and Brown (1980) with the main goal of developing a metacognitive science teaching framework drawn from multi-method lens. Initially, a survey to 324 science teachers in 49 schools of four (4) Philippines-Department of Education (DepEd) Divisions was conducted using Metacognitive Awareness Inventory for Teachers (MAIT) (Balcikanli, 2011). Subsequently, two (2) focus groups and nine (9) one-on-one interviews were organized. Investigated endogenous and exogenous variables of metacognition in science teaching were analyzed in a six-stage structural equation modeling. Results indicate that the six metacognitive factors of teacher metacognition using two-component model achieve the goodness-of-fit (Schumacker & Lomax, 2010; Kline, 2011) metrics. These six factors as observed variables are significant predictors of the respective latent constructs. Additionally, using Braun and Clarke's six-phase thematic analysis framework, codes were generated from interview transcripts and examined. Findings of the study revealed what the elements of metacognitive teaching are, suggesting the requirements of metacognitive environment in teaching and how it can be developed. Finally, the generated model of metacognitive teaching presents attributes and essential qualities of a science teacher.

Keywords: Metacognition, metacognition in science teaching, science education, Philippine education, metacognitive science teaching model



1. Introduction

Flavellian metamemory concept (Flavell, 1987; 1979), now metacognition, is a popular educational, instructional and developmental psychology concept. Flavell perhaps, has the most cited definition of metacognition which is "thinking about thinking" (Hartle, Baviskar & Smith, 2012; Hartman 2002; Joyner, 2015). Deriving the contextual definition from a forty-year old metacognition research field, it refers to a person's ability to monitor and control his own cognition (Young & Fry, 2008). When one becomes aware of his own thinking or thought via cognitive processes and ably manages that thought (Kuhn & Dean, 2004; Martinez, 2006), that can be referred as metacognition. Metacognition is a composite of cognitive knowledge and cognitive regulation. Cognitive knowledge, according to Brown (1987) may be referred as person and task knowledge (Flavell, 1979), self-appraisal (Paris & Winograd, 1990), epistemological belief (Kuhn & Dean, 2004), declarative knowledge (Schraw, Crippen, & Hartley, 2006). Altogether, these four subcategories of knowledge focus on the knowledge about oneself, and further, considered as factors affecting cognition. Such knowledge of cognition is extended to procedural knowledge (Cross & Paris, 1988; Kuhn & Dean, 2004; Schraw et al., 2006) and strategy knowledge (Flavell, 1979) which may be referred as one's awareness of cognition and knowledge of strategies. Cognitive regulation, on the other hand, is a composite of planning, regulation (or termed in other studies as monitoring), and evaluation (Schraw et al., 2006; Whitebread, Coltman, Pasternak, Sangster, Grau, & Bingham, 2009). Contrary to this, Veenman, Van Hut-Wolters and Afflerbach (2006) offered a seemingly different typology of metacognition as metacognitive knowledge and metacognitive skills.

Metacognition is a complex concept and researchers may not necessarily conform with another as to its universality. To Veenman and colleagues (2006), metacognition has yet to be defined, hence research may present various nomenclatures of metacognition. Perhaps, some researchers may view it similarly while some perceive it differently, as taxonomies continuously develop and emerge. Schraw et al. (2006), for instance, presented the categories or components of self-regulated learning (SRL) as cognition, metacognition, and motivation. Self-efficacy, along with epistemological beliefs is a motivation subcomponent of science SRL. In this particular context, metacognition is a subordinate of SRL, contrary to that of Fatin Aliah Phang binti Abdullah (2009) who contextualizes metacognition components in instruction as goals,



objectives, metacognitive knowledge, and tasks. However, one of the early pioneers like Brown (1978) refers metacognition components or its taxonomy as knowledge about and regulation of cognition often referred by most recent metacognition researchers (Mokos & Kafoussi, 2013; Arslan & Akin, 2014; Botsas, 2017).

Very notably, the classroom has morphed as conditions external to classroom demand positive changes. It is, therefore, imperative to improve science classrooms or never to leave science classrooms behind. Metacognition serves as nexus, a link, to effective science teaching and learning (Butterfield, 2012). A popular Einsteinian quote, "It is the supreme art of the teacher to awaken joy in creative expression and knowledge", reflects on teacher's supreme power direct metacognition, to which initiation of sound interaction shall emanate. Thus, a classroom shall promote learning through that teacher's art, referred today as facilitation. In consonance, Vanderlick (nd) envisioned the classroom to be an inviting ambience, not mere physical space or room, since it is a special place where learning events may actually take place and get accomplished, where it has become a ground for feedback and exchange. Hence, a typical science classroom appropriates the teacher, the learner, the learning events, and shaping mechanism outside its sphere.

Earlier reports validated decades of findings and extensive research in metacognition holding that metacognition improves teaching as it later translates into enhancing student achievement. Teachers become more strategic (Karably & Zabrocky, 2009) if there is awareness on their metacognitive knowledge and ability to demonstrate it with appropriate metacognitive skills. A large base of metacognition research in the last four decades has been done in recent intensive literature reviews conducted by Ellis, Denton, and Bond (2014); Lai (2011); Karably (2009); Veenman and colleagues (2006). Evidently, metacognition has a crucial role in science education (Kirbulut, 2014). The classroom, if not the best way or best laboratory for studying metacognition serves as the most favorable ground for metacognition studies. It is in this respect that this investigation revolves in inquiring metacognition in science teaching, and this would specifically examine how can metacognition in science teaching be modelled in terms of teachers' knowledge about cognition, and their regulation of cognition.

2. Body of paper

2.1 Introduction

Teachers are important in the student's thinking process. In turn, student's presentation of feedback is a sense of teaching improvement. Along with metacognition, self-regulation, motivation, and self-efficacy have extensive research base in education. Certainly, the teacher is a noted factor in the teaching-learning process. Accordingly, Curwen and colleagues (2010) emphasized that when teacher's metacognition increases, higher learning is developed. In agreement, Veenman and colleagues (2006) stressed that it is particularly from teachers whom students can acquire metacognitive knowledge and skills, aside from their parents and peers. Teachers are at the forefront of learning, and so with metacognition. However, with the known influence of teacher metacognition on learners, the discussion in the succeeding sections may cut across and interlace learner and teacher metacognition.



Recent studies call for revisiting, recognizing and investing for teachers' metacognition (Curwen et al. 2010). This is evidenced by studies formulating capacity building programs and teacher training programs (Fang, Angie, & Ricci, 2016; Cherubini, Kitchen, Goldblatt, & Smith, 2011). Thang, Sim, Mahmud, Lin, Zabidi, and Ismail (2014) reported that digital storytelling, an innovation drive for language skills learning has been found to develop conceptual as well as technological skills which is aligned to the skills requirements of the labor economy. While some studies are investigating at complementary perspective involving student and teachers' metacognition (Yusof, Roddin, & Awang, 2015), there are inquiries driving on studying metacognition independently e.g., metacognition in teacher's teaching. Looking at how teachers manifest in their teaching the teaching of metacognition complicates the traditional belief that metacognition cannot be taught, as it is considered an intrinsic and innate learning faculty. Although there are schools of thought contradicting the teaching of metacognition, El Soufi and See (2019) provided that explicit instruction was found to have the best evidence of effectiveness of teaching critical thinking, in relax conditions.

2.2 Methods

The worth and strength of both qualitative and quantitative research methodologies were capitalized in this study. Employing mixed methods as the overarching strategy that is appropriate in addressing the main research problem was done in order to integrate the effects of qualitative and qualitative data presented in this study. This methodology is in congruence with the underscoring previous recommendations of Snyder and Dringus (2014) and Lai (2011). The study gathered mixed methods flavor emphasized by Creswell (2014) who posited that mixed method is favored because of its strength in drawing on both qualitative and quantitative research and in minimizing the limitations of both approaches. Generally, this sequential explanatory mixed methods (QUAN→qual) was framed at Explanatory Design – follow-up explanations model to explain the quantitative results using qualitative data as follow-up. At the end, the convergence of the data would lead to the development of a model (Plano Clark & Creswell, 2008).

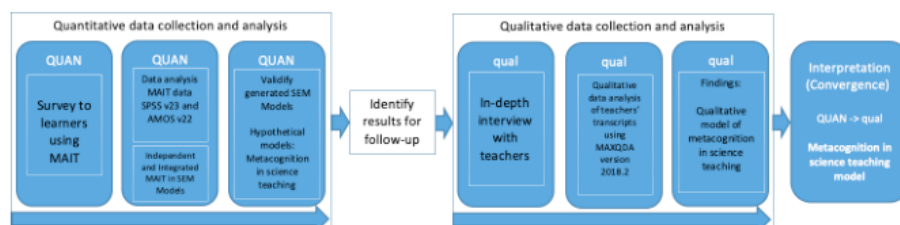


Figure 1. Operationalized mixed method sequential explanatory design. Operationalized mixed method sequential explanatory design to determine and explore metacognition in science teaching.

Multi-method approaches were used to examine the aspects of metacognition in science teaching (Figure 1). The initial stage, called the quantitative phase of the study, the teachers were surveyed on their metacognitive awareness using Metacognitive Awareness Inventory for Teachers (MAIT). In this manner, the teacher metacognition may be ascertained that would provide the prior data utilized in describing hypothesized statistical models. Next, the



subsequent stage called the qualitative phase of the study, the metacognition constructs, considered latent construct in the quantitative models, were examined as to how they used their metacognition. This was done by tapping a subset of teacher-participants. Finally, the research tried to integrate, what Plano Clark and Creswell (2008) and Creswell (2014) called convergence of quantitative and qualitative results to arrive at a fuller interpretation of the study.

Phase 1 is the quantitative phase of the study which determined the goodness-of-fit of the metacognitive factors of teaching which resulted from a survey of the metacognitive awareness of science teachers. Phase 2 is the qualitative phase of the study which involved the validation of the quantitative model generated from interviews to a subset group of volunteer science teachers. Thus, this chapter presents the analyses and exploration of metacognition in science teaching including the pre- and post-analyses measures centrally of the hypothesized metacognition in science teaching model – the conceptual frameworks of the study, that described the study's construct, termed as metacognition in science teaching, which is considered another major element of the proposed metacognitive teaching-learning environment (LTE).

Results and Discussion

The following reports contained the initial a survey that has been undertaken to 324 science teachers using MAIT. This section discusses the quantitative hypothesized metacognition in science learning models derived from structural equation modeling. From MAIT original dataset retrieved (i.e. 324), all of the teachers completed the important part of the inventory, therefore no data were discarded and neither data imputation was explored, in the absence of missing data. Mahalanobis distance (D_M) was used to determine the presence of multivariate outliers (Schreiber, Nora, Stage, Barlow, & King, 2006). For MAIT, 12 outliers were found with combination of dataset with $D_M=1$ ($p < 0.01$). To this effect, the researcher removed 12 MAIT datasets, so the final sample size was 312.

In order to proceed with any parametric test, assumptions of normality should be met. Visual inspection of MAIT dataset's histogram and normality plots were ascertain and evidently, science teachers' score in six MAIT factors were approximately normally distributed. The shape of distribution as to skewness and kurtosis was also presented determined. Based on literature, the cut-off for skewness and kurtosis is -1.50 to +1.50 using maximum likelihood (ML) estimation (Schumacker & Lomax, 2010), however, the absolute value larger than two, for skewness, and absolute value equals to seven for kurtosis may be used as reference when the sample size is 300+ (Ghasemi & Zahediasl, 2012; Mayers, 2013; Kim, 2013). The MAIT score dataset is negatively skewed and the kurtosis of all most of these dimensions are leptokurtic ($\gamma_2 > 0$), except for teachers' evaluating which is platykurtic ($\gamma_2 < 0$). On the other hand, Kolmogorov-Smirnov (K-S) statistic was not used. An approximately normal data indicate that K-S must be insignificant ($p > .05$), but due to large sample size involved in the study, e.g. >300, K-S statistic may be too sensitive, hence, making it unreliable (Kim, 2013). The processes of identifying the shape of distribution and determination of multivariate outliers are clearing house for ensuring assumptions of normality are met, in the case parametric studies like this.

As a matter of default, demographic profiling of teachers is necessary. The science teachers' profile considered in this study as follows: age range is 22-63 with mean age of 31.76 (SD=15.325), the majority (78%) is female, from public school system (76%). As to service, teaching experience ranges 2-38 years ($M=10.80$, $SD=9.249$). Most of the teachers (36.2%)



surveyed for this purpose specialized in biological sciences. Very few (8.3%) chemistry teachers, however, were included in this MAIT survey. A majority (51%) of science teachers have undergraduate degree in education or Bachelor of Science degree. Very few (2.2%) of them earned advanced. Science teachers were deployed as follows: 189 teachers (or 62%) in senior high school, 60 teachers (or 19%) in junior high school, and 63 teachers (or 20%) handle both junior and senior high school levels since the integrated school offers both levels of schooling.

From the data exhibited in Table 1, the six components of teachers' metacognitive awareness with its corresponding mean and standard deviation can be gleaned. These six components are typified into two categories – teachers' knowledge about cognition and teachers' regulation of cognition.

Table 1

Means and standard deviations of teachers' metacognitive factors (n=312)

Metacognitive component	Teachers' metacognitive factors	Min	Max	Mean	Std. Dev
Knowledge about cognition	Teachers' declarative knowledge	1.00	5.00	4.211	0.548
	Teachers' procedural knowledge	1.00	5.00	4.346	0.531
	Teachers' conditional knowledge	1.00	5.00	4.227	0.524
Regulation of cognition	Teachers' planning	1.00	5.00	4.189	0.511
	Teachers' monitoring	1.00	5.00	4.176	0.541
	Teachers' evaluating	1.00	5.00	4.211	0.544

Mean values and standard deviations were important to highlight and present the variability of a given data, in this case, the MAIT datasets.

Table 2

Correlations among teachers' metacognitive factors (n=312)

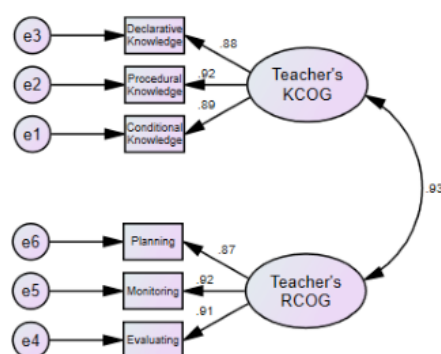
Teachers' metacognitive Factors	Teachers' declarative knowledge	Teachers' procedural knowledge	Teachers' conditional knowledge	Teachers' planning	Teachers' monitoring	Teachers' evaluating
Teachers' declarative knowledge	---					
Teachers' procedural knowledge	.75**	---				
Teachers' conditional knowledge	.69**	.75**	---			
Teachers' planning	.64**	.69**	.68**	---		
Teachers' monitoring	.65**	.67**	.69**	.71**	---	
Teachers' evaluating	.65**	.66**	.65**	.73**	.81**	---

**Correlation is significant at the 0.01 level (2-tailed)

Data in Table 2 show the correlation matrix of teachers' metacognitive factors. All of the factors are positively correlated indicating positive linear relationship. Correlation coefficient values of the factors range from 0.64 (moderate relationship) to 0.81 (high relationship). Furthermore, all factors of teachers' metacognition are significantly correlated ($p < .01$).



Hypothetical SEM of metacognition in science teaching is presented in Figure 2. This model is based on Balcikanli's (2011) Metacognitive Awareness Inventory for Teachers (MAIT). It is SEM correlational relationship of two exogenous latent constructs. The structural components are the two latent constructs cognitive knowledge (TKCOG) and cognitive regulation (TRCOG), shown as the ellipses in the model. The measurement components of the model, represented by rectangles, comprise of three endogenous variables of the TKCOG and three endogenous variables of the TRCOG.



ChiSquare=26.394; RMSEA=.085; GFI=.972; AGFI=.927; CFI=.990; NFI=.986; TLI=.982

Figure 2. Hypothetical SEM of metacognition in science teaching. This model is based on Balcikanli's (2011) Metacognitive Awareness Inventory for Teachers (MAIT).

The goodness-of-fit test indices of metacognition in science teaching hypothetical model are displayed as follows: $\chi^2 = 26.394$; $df = 8$; $p = .001$, $\chi^2/df = 3.30$, GFI = .972, NFI = .986, TLI = .982, IFI = .991, CFI = .990, PCFI = .528, RMSEA = .085, AIC = 52.39. With reference to above-mentioned indices (i.e. normed chi-square, GFI, NFI, TLI, IFI, CFI), all suggest and indicate a good fit between the hypothesized model and the observed data, except for RMSEA. The GFI is 0.97; TLI is .98; and SRMR is 0.013. No post-hoc modification was done, as good fit was noted in the data. NFI, NNFI or TLI, GFI, AGFI is satisfactory as values are $>.95$ (Weston & Gore, 2006; Hair, Black, Babin, & Anderson, 2014). Overall, the results suggest that hypothetical model of teacher metacognition is a good fit satisfying major fit indices, thus, suggesting that the model is acceptable.

Data in Table 3 indicate the standardized and unstandardized estimates for SEM sample, in this case, the teachers. It should be noted that summarized standardized regression weight estimates (β) and the regression weight estimates (B) with corresponding error (SE) of teachers' metacognition were derived using maximum likelihood estimation.

**Table 3***Standardized and unstandardized estimates for SEM sample (Teachers)*

Observed variable	Latent construct	β	B	SE
Declarative knowledge	Teachers' KCOG	0.88	1.03***	0.045
Procedural knowledge	Teachers' KCOG	0.92	1.04***	0.042
Conditional knowledge	Teachers' KCOG	0.89	1.00	---
Planning	Teachers' RCOG	0.87	0.90***	0.038
Monitoring	Teachers' RCOG	0.92	1.00***	0.038
Evaluating	Teachers' RCOG	0.91	1.00	---

*Teachers' KCOG-Teachers' knowledge about cognition**Teachers' RCOG-Teachers' regulation of cognition*

Except for conditional knowledge of latent construct, KCOG, and evaluating of the latent construct RCOG given assumed values of 1.00 (a customary practice in SEM to assign a regression weight value equal to 1.00), all other metacognitive factors of teaching are significant predictors ($p < .001$) of their corresponding latent constructs. This provides proof that teachers' KCOG can be explained by declarative knowledge, procedural knowledge, and conditional knowledge, whereas teachers' RCOG is apparently attributed to their planning, monitoring, and evaluating skills.

Another essential and complementing part of this study comes in form of exploring the teachers' use of metacognition in science teaching using qualitative methodology. Transcripts of the interview were studied, then codes generated, and then finally the clustered codes were thematized. To stress an overview of the generated codes, Figure 3 presents the top codes developed during qualitative data processing of teacher responses.

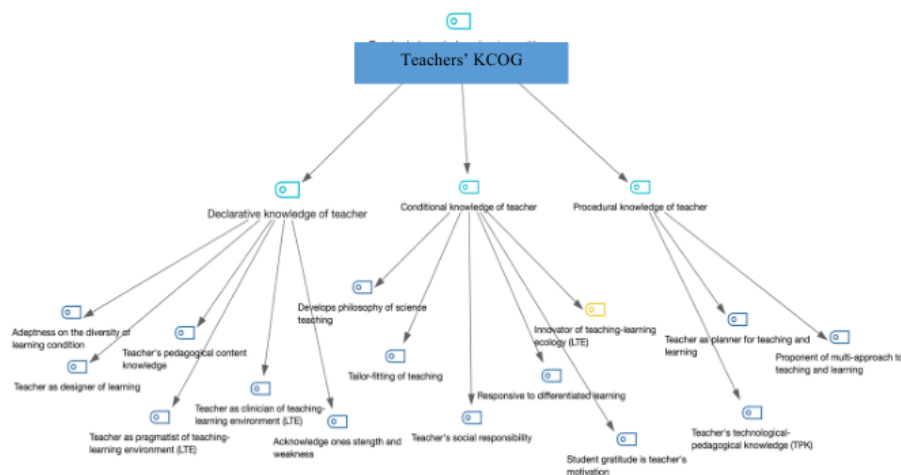


Figure 3. *Generated hierarchical model of codes-subcodes of teachers' knowledge about cognition.* The figure shows the top codes which contain 5 significant statements and above.

Initially, *a priori* codes were used as input to the qualitative data analysis software code



system to serve as the main codes (mother code) and sub-codes (daughter codes). The two general codes are teachers' knowledge about cognition (cognitive knowledge) and the teachers' regulation of cognition (cognitive regulation) – the latent construct described in the previous chapter. Besides, the subcodes, the very constructs derived from MAIT – teachers' declarative knowledge, teachers' procedural knowledge, teachers' conditional knowledge, planning, monitoring, and evaluating. In the process, generated codes in each main and sub-codes had to be fused whenever they reached and became mature and then integrated to build substance in constant comparison to the conceptual or definitional grounds of the *a priori*. No codes stemmed as hierarchical as the main or mother codes.

Teachers' Knowledge about Cognition (KCOG): *Declarative Knowledge, Procedural Knowledge, and Conditional Knowledge*

Three main variables helped discuss the teachers' knowledge about cognition (cognitive knowledge) that resembles the learners' knowledge about cognition presented in the earlier part of this chapter. Unsurprisingly, teachers' metacognition has the same dimensions or metacognitive factors as learners' metacognition since it was contextualized using MAI, then Balcikanli (2011) introduced MAIT. MAIT is an adult metacognition instrument, a product of instrument examination using dimension reduction technique of confirmatory factor analysis (CFA). The dimensions comprise of declarative knowledge, procedural, and conditional knowledge.

Teachers' Declarative Knowledge. Teachers' declarative knowledge was inquired from teachers as they answered the question, "*How do you utilize being a "good science teacher" to deliver your day-to-day tasks?*" Furthermore, teachers were interviewed about their strengths and weaknesses, the skills that make them good science teacher, and the indicators that they are in control of such as planning for instruction, developing activities, executing of the instruction in class, making assessment tasks. In all of these sessions, the teachers' coded responses were directed towards the following themes: Teacher Teacherhood, Teacher Quality, and Teacher Effectiveness. The first clustered code is Teacher Teacherhood which refers to compassionate, mindful of one's strengths and weaknesses, adept to understand learner diversity, and goal of teaching. The codes strong sense of organization, pedagogical content knowledge, and building democratic classroom correspond to clustered code Teacher Quality. Teacher Effectiveness, on the other hand, signifies positive attitude, sense of humor, designer of learning, teacher as pragmatist, and teacher's clinical role. Being a good teacher demands that one achieves certain level of teacherhood, manifest teacher quality and degree or level of performance for which one will be assessed effective. Table 5 summarizes these themes and codes for discussing the teacher's declarative knowledge. Therefore, Teacher Excellence is framed using the constructs Teacher Teacherhood, Teacher Quality, and Teacher Effectiveness.

Teachers' declarative knowledge can be attributed to their teacherhood, quality, and effectiveness. The derived teacherhood is qualified by the teacher's compassion and mindfulness of one's strength and weakness, while teacher quality may be defined as teacher's strong sense of organization, the capacity to build democratic classroom where every learner has the opportunity to participate. Teacher quality is also equated with his/her expertise of delivering content appropriately via teacher's PCK. Finally, it is positive attitude, humor, pragmatism, design and clinical role that considerably manifest teacher effectiveness.

**Table 4***Summary of themes qualifying teachers' declarative knowledge*

Theme 1 Teacher Teacherhood	Theme 2 Teacher Quality	Theme 3 Teacher Effectiveness
• Compassionate • Mindful of one's strength and weaknesses • Adept in understanding learner diversity • Goal-directing	• Strong sense of organization • Building democratic classroom • Pedagogical content knowledge	• Positive attitude • Humor • Pragmatic • Designer of learning • Clinical role

In some instances, the research might see overlapping codes due to similarity in context of constructs (e.g. teacher effectiveness vis-à-vis teacher quality, teacherhood vis-à-vis effectiveness, and quality vis-à-vis teacherhood), however, the examples revealed in each response served as demarcation line of each theme. The metacognitive knowledge of a teacher reflects his/her attributes of compassion, mindfulness, and adeptness in understanding learning for teacherhood; strong sense of organization, building democratic classroom, and teacher's PCK for quality, and positive attitude, pragmatism, designer and clinical roles of the teacher for effectiveness.

Teachers' Procedural Knowledge. In this context, the teacher's procedural knowledge shows in his/her knowledge or awareness of thinking processes. The activities leading to the individuals' ability to summarize and create inferences are entirely procedural. The main question for *procedural knowledge*: *What science teaching technique/s can you showcase which you can describe in detail because it worked best in the past?* The response of teacher-participants may be thematized as qualities of effective teacher, as gleaned in the presentation in Table 5.

Table 5*Teachers' demonstration of procedural knowledge*

- Encourage the use of manipulatives to enhance laboratory skills
- Incorporate related IT skills in teaching
- Use visual strategies in teaching
- Promote the use of higher order thinking skills

Teachers' procedural knowledge put altogether what makes teacher self-efficacious, a theme that revolves around what teacher's do in order to excite the transfer of metacognition to the learners. Their procedural knowledge is manifested in incorporating teaching activities that will encourage the use of manipulatives, the incorporation of related IT skills which has found their indispensable tools required in modern teaching and learning, the use of visual strategies in teaching to complement visual learning, and the promotion of HOTS. Procedural knowledge, thus, can be defined as teachers' translation of their teaching, as manifested in the use of manipulatives, utilization of essential IT skills, the emphasis in practicing visual pedagogies that all lead to promoting high-order thinking skills.



Teachers' Conditional Knowledge. The knowledge on cognitive regulation called conditional knowledge is centrally aligned with the-how-and-when-to-use the declarative knowledge and procedural knowledge. The teachers' conditional knowledge is manifested they understand that the use of metacognitive strategies is dependent on the situation. Wilson and Bai (2010) stressed that a particular situation will necessarily require particular strategy, and a metacognitive teacher must be skillful enough to diagnose it.

The main question for *conditional knowledge*: *What are your motivations to teach effectively?* Also, the following probing questions were asked: *Cite situation in which your strengths in teaching science is considered effective, the teacher's motivation to really teach, and specific situation in which the teacher uses procedures that produce better science learning.* All answers or teacher responses were used to flesh out the following themes: (1) Elements of Pedagogical Adeptness and (2) Drivers of Pedagogical Innovation. These emerging constructs were the springboard in defining what Teacher Innovativeness is in order to reflect teacher's conditional knowledge.

Table 6
Elements and drivers of teachers' conditional knowledge

Theme 1	Theme 2
Elements of Pedagogical Adeptness	Drivers of Pedagogical Innovation
•Teachers' tailor-fit teaching •Teachers' valuing •Teachers' motivation •Teachers' social responsibility •Development of philosophy of science teaching •Responsive to differentiated learning •Appeal to emotion •Personal belief	•Innovating classroom strategies •Creating educational products to aid learning

Teachers' Regulation of Cognition (RCOG): Planning, Monitoring and Evaluating

The study's constructs, cognitive regulation of teachers were all drawn from the same concept introduced by Brown (1980) and Schraw and Dennison (1994). In context, the only variation that separates teacher metacognition from learner metacognition is the expectation that certain level of maturity and executive role teachers manifest and perform. The teacher's ability to direct his/her learning via planning, monitoring, and evaluating all entails the activities for regulating cognition (Ozturk, 2017). Three main variables or subcomponents emerge in this discussion: teachers' planning, teachers' monitoring, and teachers' evaluation.

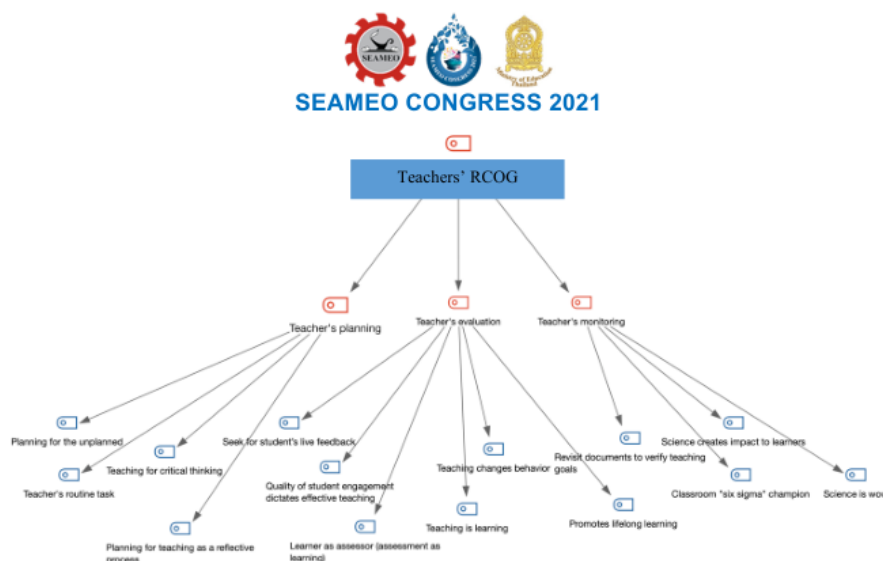


Figure 4. Generated hierarchical model of codes-subcodes of teachers' regulation of cognition. The figure shows the top codes which contain 5 significant statements and above.

Figure 4 highlights the generated codes the research had developed on cognitive regulation which were thematized using Braun and Clarke (2006) top-down method of theoretical analysis. The contemplation on this metacognitive component was anchored on the following main questions – for Planning: *How do you organize yourself prior, during, and after your teaching tasks?* – for Monitoring: *What do you do to check that your teaching matches your goal?* and for evaluating: *How will you know that you teach science well or teach effectively well?*

Teachers' Planning. Teachers set goal and allocate teaching resources, all these activities conform to their planning knowledge. Planning is the metacognitive layer that one employs when approaching a task (Ku & Ho, 2010). Zepeda, Richey, Ronevich, and Nokes-Malach (2015) theorized that planning, one of the metacognitive skills, interplays with self-regulation (or self-regulated learning, SRL) among adult learners (e.g. teachers) to enable the adult to recognize the purpose of the problem and the strategic direction to move towards the goals. In this particular instance, teachers were asked about their teaching preparations, the specific teaching goals, and the time organization congruent to the stated goals. Teacher's planning skills is anchored in Zimmerman and Schunk (2011) SRL Model. Zimmerman (2002) approached planning as a significant sub-process of task analysis. In this direction, the discussion focused, thus, according to the two themes generated: (1) Reflective Thinking, and (2) Strategic Planning.

The teachers' ability to regulate cognition that involves critical thinking, reflective process, grit, and formulation of contingencies all together characterize planning skills. Teachers' planning knowledge is magnified by their cognitive and non-cognitive faculties. Teachers' planning is a critical process and the knowledge described as a composite of reflective thinking and contingency planning, as shown in Table 7. Teachers are mindful of actual teaching-learning processes and with this knowledge comes with careful consideration of the learners' development that is central to the work of the teacher.



Table 7
Characteristics of teachers' planning skills

Theme 1 Reflective Thinking	Theme 2 Strategic Planning
• Critical thinking • Reflective process	• Grit • Routine task • Contingencies

Teachers' Monitoring. The regulatory cognitive monitoring function or mechanism assesses one's teaching or strategy use in the classroom. Previously, teachers' planning was centrally focused on goals, at this very point, monitoring is about science teaching meeting the goals. The assessment of teachers' teaching of science and ultimately, the checking of learners' comprehension. Gopinath (2014) affirmed Flavell's (1979) and Brown's (1980) cognitive monitoring as a component of regulatory mechanism where a person checks his/her own understanding to determine the effectiveness of an attempt to solve a task using that understanding. Hence, there is a developed switching strategies as one learns how to alter from one strategy to another.

Flavell's (1979 cited in Louca, 2003) cognitive monitoring model may be capitalized as the model stressed the cognitive enterprises, the dynamic interaction of four constructs beginning with cognitive goals (essentially the tasks), then metacognitive experiences, metacognitive knowledge, and cognitive actions (the strategies). Although the realm of discussion leans on the learner as the thinker, it is but equitable to bring teachers in equal footing, since they are part and parcel of the community of learners. As Dewey posited, teachers are learners as well. There are two dimensions of teacher's monitoring knowledge thematized as: Social Dimension of Science Impacting the Learners and Impact of Science to Oneself, who is the teacher.

Table 8
Summary of teachers' monitoring knowledge/skills

Theme 1 Social Impact of Science	Theme 2 Impact of Science to Oneself
• Social Dimension of Science Impacting Learners • Science is Wow	• Revisit documents to verify teaching goals • Classroom champion

Inevitably, the finding that there is a way by which the teacher measures teaching process, ultimately emerges with its impact on the learners. To illustrate, the teaching of science does not stop in discovering and mastering the concept, it is optimally significant, if the teacher sees to it that it helps student change for the better (i.e. change in attitude and behavior, as evidenced by better performance). In this context, teacher monitoring as teachers' regulative process impacts on science in the context of social dimension contributing change in behavior and performance.



Teachers' Evaluating. The revised Bloom's taxonomy of educational objectives (or the Anderson and Krathwol's Taxonomy, 2001) emphasized that evaluation is a high-order thinking skills, as it values criteria-based judgment (Zawilinski, 2009). As constantly stressed, that metacognition sets reflective practice of teaching, while evaluation completes the ingredients of the reflective teacher, hence, regulatory mechanism of metacognition works towards one's reflective enterprise, which, according to Rahman (2011) embraces by planning, monitoring, and evaluation.

Teachers' ability to analyze their performance and strategize effectiveness after a teaching episode is called the regulatory mechanism of evaluation. In the conduct of this study, teachers were asked to describe how well they effectively teach. In the following articulations, teachers presented their own evaluation of teaching. When one is explicit and conscious in controlling his/her own thoughts and action, as well as memories, these are overt conditions of evaluating knowledge (Rahman, 2011). Parallel to this stance, a previous discussion about learner's evaluation serves also as good reckoning point. The sole theme directing the discussion in this part is transformation of teaching-learning. Teaching is a multiple composite of metacognitive qualities. Teaching changes behavior, teaching is re-learning, quality of student engagement dictates effective teaching, and students' live feedback in developing the theme called Transformation of teaching-learning which, in turn, explained as Teacher Transformation.

Table 9

Teachers' evaluating knowledge

Theme: Transformation in Teaching-Learning

- Teaching changes behavior
- Teaching is re-learning
- Quality of student engagement dictate effective teaching
- Students' live feedback
- Promotes life-long learning

Complementary studies were conducted for the purpose of understanding the nature of variable, hence in this study, the quantitative and qualitative aspects of metacognition in science teaching. The hypothetical models of metacognition in science teaching were based on the Metacognitive Awareness Inventory for Teachers (MAIT) by Balcikanli (2011) whose constructs emanated from Metacognitive Awareness Inventory (MAI) by Schraw and Dennison (1994). Using structural equation modeling (SEM), the latent exogenous variables called teachers' knowledge about cognition (TKCOG) and teachers' regulation of cognition (TRCOG) exposed in the six endogenous variables or metacognitive factors (i.e. declarative knowledge, procedural knowledge, and conditional knowledge for TKCOG; and planning, monitoring, and evaluating for TRCOG) were carefully studied and explored. The results suggest that the hypothetical models of teacher metacognition, i.e., metacognition in science teaching, attained good fit satisfying major fit or the global fit indices, thus, indicating that the structure of two-factor teacher metacognition model is acceptable.

An equivalent activity was undertaken to explore the metacognition in science teaching in the qualitative phase of the study that apparently described the qualities of the teacher in a metacognitive environment – S/He shall possess excellence, encouraging teaching disposition,



and innovativeness for the teachers' knowledge about cognition, while other attributes embracing teachers' regulative mechanism of cognition include grit, transcendence, and transformation. The teachers' knowledge about cognition – is the teachers' declarative, procedural, and conditional knowledge were assumed by the constructs teacher excellence, teacher encouragement, and teacher innovativeness. Teacher excellence is anchored on teacherhood, teacher quality, and teacher effectiveness. Teacher encouragement equates to efficacy, while innovativeness refers to teacher pedagogical adeptness to innovate.

On the other hand, regulation of cognition reflects the teachers' knowledge on planning, monitoring, and evaluating were implicitly represented by the constructs on teacher grit, teacher transcendence, and teacher transformation. Teachers' regulatory metacognitive knowledge with regard to current undertaking demonstrated, perhaps, the complete elements of metacognitive teaching. The grit of a teacher refers to his/her capacity to reflect critically and plan strategically with full know-how on contingencies. Teacher transcendence means going beyond attitude of the teacher, the execution of all his/her faculties across boundaries of difficulties experienced in the classroom, and teacher transformation that refers to teaching-learning environment, i.e., teaching leads to changes in the learner and the teacher as well. These changes create meaningful teaching that parallels metacognitive student experience called meaningful learning. Meaningfulness in teaching is an extract, a concept, from teachers who, by constant comparison, unceasingly stand by their learners and demonstrate the value of achievement and change for the better of the learner as well as offer academic and moral help to all kinds of learners. S/he is a very willing teacher who integrates innovation in practicing the profession.

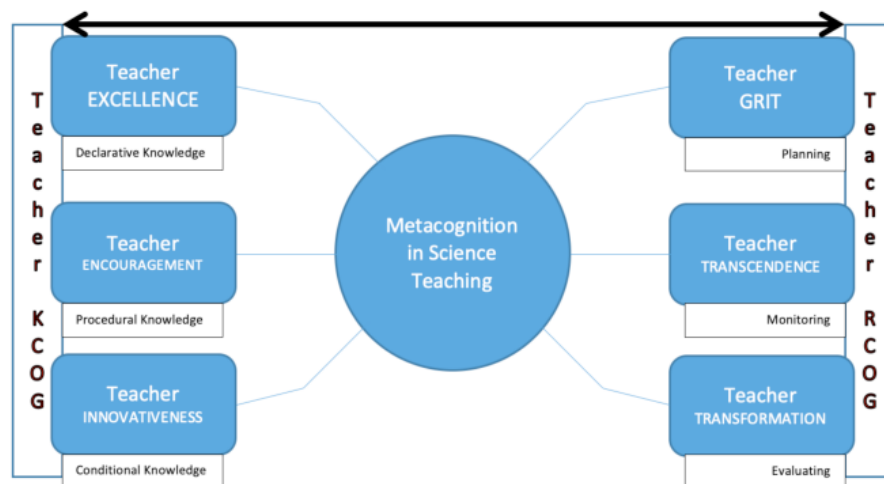


Figure 5. *Metacognition in science teaching model.* The integrative metacognition in science teaching model exposing the elements or attributes of metacognitive teaching.



As presented in Figure 5, teachers' knowledge about cognition is thematized as teacherhood, quality, and effectiveness; teacher efficacy; and pedagogical adeptness and innovativeness. Moreover, the cognitive regulation (or regulation of cognition), as complementary metacognitive peripheral, is themed as reflective thinking and strategic planning for planning competencies, social impact and impact to oneself for monitoring awareness and transformation teaching-learning for evaluating enterprise of the teacher. Teacher metacognition, therefore, as two-composite construct of knowledge about and regulation of cognition can be qualitatively modeled, as presented in Figure 5.

The qualitative model was anchored on the two-factor metacognitive attributes of metacognition according to Flavell (1979), Brown (1980), and Schraw and Dennison (1994) and recently showed consistent with that of Magno's (2010) two-factor model. The model reiterates knowledge about cognition and regulation about cognition. In previous chapters, hypothetical models were presented and findings had shown congruence with those of Lee, Teo, and Bergin (2009), Teo and Lee (2012).

Tables 10 and 11 provide the operational definitions that this dissertation aspire to share. These tables contain the contextualized definitions of the variables teachers' knowledge about cognition and teacher's regulation of cognition.

Table 10

Operational definitions of TKCOG themes in metacognitive teaching

Metacognitive components	Metacognitive factors	Definition context
Teachers' KCOG	Declarative knowledge	Themes: <i>Teacher teacherhood, teacher quality, and teacher effectiveness</i> . The metacognitive knowledge of a teacher reflects teacher attributes of compassion, mindfulness, and adeptness in understanding learning for teacherhood; strong sense of organization, building democratic classroom, and teacher's pedagogical content knowledge (PCK) for quality, and positive attitude, pragmatism, designer and clinical roles of the teacher for effectiveness.
	Procedural knowledge	Theme: <i>Teacher efficacy</i> . Teacher's procedural knowledge is translated as the teacher's use of manipulatives, essential information technology (IT) skills, and the emphasis in practicing visual pedagogies which all lead to promoting high-order thinking skills.
	Conditional knowledge	Themes: <i>Elements of pedagogical adeptness and drivers of pedagogical innovation</i> . Conditional knowledge of the teacher presents teacher pedagogical adeptness observed in tailoring teaching, valuing; motivating, and developing philosophy of science teaching; and pedagogical innovativeness relative to teacher's engineering of classroom strategies and creation of educational products.



Teachers' knowledge of cognition may be referred to as teacher attributes manifesting teacherhood, quality, and effectiveness and teacher's emphasis on pedagogies that promote high-order thinking skills exhausting pedagogical adeptness and pedagogical innovation.

Table 11

Operational definitions of TRCOG themes in metacognitive teaching

Metacognitive components	Metacognitive factors	Definition context
Teachers' RCOG	Planning	Themes: <i>Reflective thinking</i> and <i>strategic planning</i> . Teachers' ability to regulate cognition which involves critical thinking, reflective process, grit, and formulation of contingencies that all together characterize planning skills.
	Monitoring	Themes: <i>Social Impact of Science</i> and <i>Impact of Science to Oneself</i> . Teachers' regulative process which sees impact of science in the context of social dimension contributing change in behavior and performance.
	Evaluating	Theme: <i>Transformation in Teaching-Learning</i> . Teacher's evaluating knowledge qualifies changes in behavior and continuously solicits feedback for more effective teaching with the end goal of promoting life-long learning.

Teachers' regulation of cognition implies the ability to think critically and reflectively with grit for more effective teaching, the end goal of promoting life-long learning. Expectedly, it brings about transformation in the teacher in the teaching-learning continuum.

3. Conclusion

Metacognition in science teaching, on the other hand, may be fostered by harnessing reflective practice whose elements are teacherhood, teacher quality, and teacher effectiveness. In this context, teacher encouragement is equated to efficacy while innovativeness is referred to pedagogical adeptness of teacher to innovate. By contrast, the derived qualities of teacher – grit, transcendence, and transformation regulate his/her metacognition. Teacher metacognition is about what teachers' feel about their own teaching. The science teaching model specifies the typical teacher who is able to deliver and traverse to meaningful learning experienced by the learners that eventually morphs into meaningful teaching. Moreover, the model typifies teacher who can design metacognitive teaching-learning environment (LTE) depending on classroom requirement or the learners' quality.

Consistently, the elements of metacognitive teaching exposing teacher qualities are critical in the development of metacognitive teaching-learning environment. Teaching and learning are complementary activities, hence, metacognitive learning and metacognitive teaching as congruent aspects may effectively foster and renew passion for learning and teaching.



Finally, schools need to foster and create an environment where teachers can respectively teach metacognition. A half-century of metacognition research has proven its efficacy to influence performance and attitudinal dimensions, promotion for transfer in all aspect of teaching-learning process is highly encouraged. It is within the academic community to cultivate metacognition. If metacognition has found a place in a very conventional classroom, the onset of the fourth industrial revolution sets a mature metacognitive teaching-learning environment. Utility of the models can be adopted to foster collaboration with the end goal of providing teachers with transformative experience that will mold their teacherhood, adept to minimize classroom inadequacies and complement them with necessary transcending qualities.

Acknowledgment

This paper was funded by the Department of Science and Technology-Science Education Institute.

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RESEARCH ARTICLE 18

A Review on Larvicidal Activity of Silver Nanoparticles Derived From *Ficus* spp. Against *Aedes aegypti*

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ScienceOpen Preprints

Original publication: 2022



Article title: A Review on Larvicidal Activity of Silver Nanoparticles Derived From

Ficus spp.

Against

Aedes aegypti

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Preprint statement: This article is a preprint and has not been peer-reviewed, under consideration and submitted to ScienceOpen Preprints for open peer review.

DOI: 10.14293/S2199-1006.1.SOR.PPUOPF7.v1

Preprint first posted online: 12 May 2022

Keywords: *Aedes aegypti*, Dengue virus, *Ficus* species, Insecticidal resistance, Silver nanoparticles

A Review on Larvicidal Activity of Silver Nanoparticles Derived From *Ficus* spp. Against *Aedes aegypti*

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ABSTRACT

Insecticidal resistance among mosquitoes has become prevalent due to the continuous use of insecticides to control dengue vectors. This became the catalyst for researchers to come up with an alternative that is mainly organic and biologically synthesized from plants. Silver nanoparticles are widely known as one of the effective alternative larvicides since it has the silver's bactericidal capabilities, the larvicidal activity of the chosen plant, and excellent effectiveness due to its small particle size which measures around 1 nanometer to 100 nanometers, as well as the excellent surface area to volume ratio. Different plant parts such as leaves and fruits from some *Ficus* spp. are widely used and studied in deriving silver nanoparticles to test their larvicidal activities against dengue vectors. Researchers discovered that this is due to the plant extracts from most *Ficus* spp. which contain phytochemical components that are known for having a huge role in ferric reduction and radical scavenging actions. Most researchers used advanced analytical methods to explore the characteristics of the derived silver nanoparticles and used WHO protocol in testing the effectiveness in combating dengue vectors. This review will discuss the possibility that silver nanoparticles derived from an indigenous plants, which are *Ficus* species, can be a feasible alternative to combat dengue outbreaks.

Keywords: *Aedes aegypti*, Dengue virus, *Ficus* species, Insecticidal resistance, Silver nanoparticles

INTRODUCTION

Dengue fever is a mosquito-borne virus that has recently spread to many parts of the world. Mosquitoes commonly transmit Chikungunya, yellow fever, and Zika viruses. The virus is expected to cause 100-400 million illnesses per year. Early diagnosis and adequate medical care can reduce severe dengue mortality to under 1%. Some patients develop severe dengue, affecting various body systems. The virus has four serotypes that can coexist in the same area: bleeding, organ damage, and plasma leakage. Many countries have all four serotypes. (WHO, 2022)

The *Aedes aegypti* mosquito transmits the dengue virus. In addition to the black and white pattern on its legs and other body parts, *Aedes aegypti* adults have white and silver scaly spots on a black background. (European Centre for Disease Prevention and Control, n.d.) They prefer humans because they allow them to rest and seek hosts. *Aedes aegypti* thrives in urban areas with abundant oviposition sites. Human activities such as outdoor water storage must be targeted to control this species. Reducing mosquito populations is more effective than using insecticides and focusing on source reduction.

The *Ficus* genus comprises roughly 850 woody trees, shrubs, vines, epiphytes, and hemiepiphytes. They are endemic to the tropics, with a few species expanding into the semi-warm temperate zone. There are roughly 150 species endemic to the Philippines, a tropical country; among these are *Ficus casiguranensis*, *Ficus camarinensis*, *Ficus microcarpa*, and *Ficus religiosa*, *Ficus racemosa*, *Ficus benjamina*, *Ficus vallischooudae* Delile, *Ficus septica* and, *Ficus benghalensis*. The *Ficus* spp. is extensively used for traditional medicines for different diseases and conditions, such as *Ficus casiguranensis* and *Ficus camarinensis* are known to have antibacterial and larvicidal activity. *Ficus microcarpa*, *Ficus religiosa*, and *Ficus racemosa* are traditionally used for Diabetes, inflammation, and

skin diseases. At the same time, *Ficus microcarpa*, *Ficus benamina*, and *Ficus septica* are also good sources of fiber and latex.

Silver nanoparticles are becoming more common in biomedicine. Silver nanoparticles are less than 100 nm in size and contain 20-15,000 silver atoms. (PMC, n.d.) The optical, thermal, and catalytic properties of silver nanoparticles vary in size and shape. Silver nanoparticles are often used to sterilize nanomaterials in food and pharmaceutical goods, such as textiles, food storage bags, refrigerator surfaces, and personal care products. Silver is a popular antibacterial and disinfectant owing to its low toxicity. These silver nanoparticles are antibacterial and antiviral. Bacterial cell walls may be penetrated, affecting membrane structure and perhaps killing cells. Silver ions are released by reactive oxygen species, disrupting DNA replication. (Ramesh et.al, 2018)

An increase in dengue cases showed that numerous people have been affected by the disease, especially those residing in tropical and subtropical areas. As such, to manage and eliminate mosquito-borne diseases, insecticides are being applied. However, the use of insecticides possesses harmful effects both on people and the environment. Also, according to Liu (2015), despite the high effectiveness of insecticides to control vector species, it has become the root cause for the resistance of most mosquitoes leading to an increase in vector capacity. That's why newly improved insecticides are needed to manage the vector without causing harm to the environment and the non-target organisms. Plus, a type of insecticide that is not costly, thus budget-friendly, can attract a lot of consumers to use insecticides to eliminate mosquitoes-borne diseases that are roaming around their area. The use of insecticide by one person will be beneficial to all the people and the environment around them.

Because of synthetic insecticides' toxicity on the environment and humans, as well as the increasing prevalence of insect resistance it has become vital to develop new insecticides. The general objectives of the authors is to identify an alternative larvicide that would help lessen *Aedes aegypti* mosquito viruses that kill thousands of people in a year. The idea of a plant-based insecticide that is safe and effective for everyone, that is not harmful to both the environment and other living things is what the authors want to perceive. A further intention of the authors is to familiarize ourselves with plants that derived silver nanoparticles. It has been demonstrated that by combining AgNPs with insecticidal plant extracts, larvicidal compounds that are effective against mosquitoes can be synthesized. As plants are high in bioactive compounds, are effective against a small number of species, including specific insects, and are biodegradable, they could be a source of alternative mosquito control agents (Morejon et. al, 2018). In this case, the specific objective of the authors is to focus on the larvicidal activity of AgNPs extracted from different *Ficus* spp. as they have the potential to be useful in pest management strategies that are integrated. Specifically this systematic review aims to help the general community and local workers have an idea on what are the possible plant alternatives to synthetic insecticides for killing larvae or adult mosquitoes, and gain knowledge for the future researchers which may also serve as their grounds for future references and background literature.

METHODOLOGY

A. Literature Search

The researchers used different library databases which are PubMed, Google Scholar, EBSCO Information Services, and ScienceDirect to look for reliable and relevant articles and journals for the research. The keywords used were “insecticidal resistance, Dengue virus, *Ficus* spp., silver nanoparticles, larvicidal activity of *Ficus* spp., and *Aedes aegypti*”. The databases were limited to 12 years, starting from the year 2010 to 2022 but not restricted on location. A manual search was performed to narrow down the variety of sources thus making it more efficient to find information about *Ficus* spp., silver nanoparticles, larvicidal activity, and *Aedes aegypti* that the researchers needed.

B. Eligibility Criteria

The researchers use the title and abstract screening to identify the articles of interest which include credible databases such as PubMed, ScienceDirect and NCBI. It was guaranteed that resources were published in English starting from the year 2010 up to present. To that intent, the researchers limit

the inclusion to peer-reviewed papers and topic references that include silver nanoparticles, *Ficus* spp., insecticidal resistance, *Ficus* spp. *Aedes aegypti*, silver nanoparticles with larvicidal activity, green-synthesised silver nanoparticles, and silver nanoparticles

As for the exclusion, the researchers particularly excluded articles whose participants are below college students, non-English studies, and sites that are not credible such as wikipedia, social media, and unpublished studies or blogs. Moreover, studies that are outdated and published on or before 2010 and other biological activities of silver nanoparticles, other plants, chemically synthesized silver nanoparticles, other vectors, and are non-peer-reviewed are also excluded.

C. Selection Strategy

The researchers were able to identify and review the inclusions for the selected study together with its eligibility and discrepancies. The authors have scanned the title and abstract of the selected articles with respect to the full-text assessment of the acceptable research articles.

D. Data Extraction

Using a standardized form, the researchers retrieved the following study characteristics from the eligible articles which includes: (i) study characteristics (title, first author's name, journal, year of publication, country of origin, and objective); (ii) methods (research design, sample size, and duration of the study); (iii) subject characteristics (inclusion and exclusion criteria); (iv) results: the key or major findings of the study.

RESULTS

A. Study Selection

The researchers discovered a total of 10 research articles on larvicidal activity of silver nanoparticles obtained from *Ficus* species against *Aedes aegypti* from 2010 to recent year through screening of title and abstract from 62 articles collected from the initial search on ScienceDirect, NCBI, PubMed, and Google Scholar. The detailed selection procedure is provided by the PRISMA flowchart.

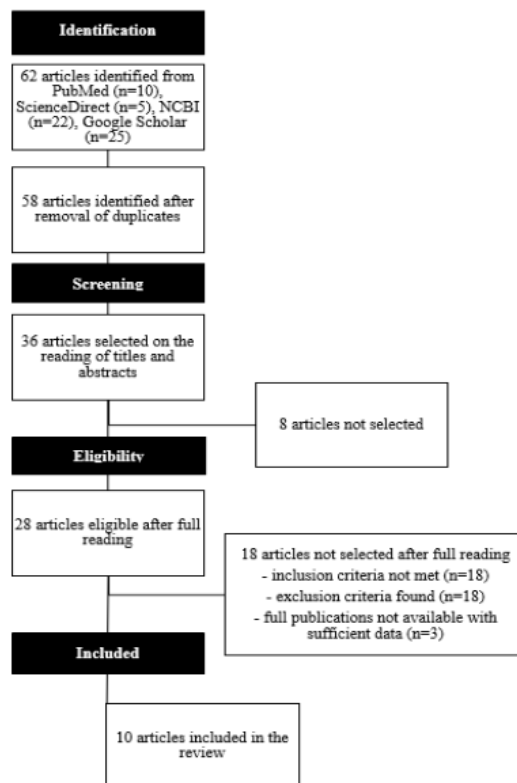


Figure 1. PRISMA Flowchart.

B. Characteristics of the Included Studies

All 10 selected articles were experimental studies, and few are cross sectional studies. The articles mainly focus on discussing the larvicidal effects of silver nanoparticles extracted from *Ficus* spp against *Aedes aegypti*. The researchers also included two articles that involve phytochemical reactions and the extract of *Ficus benghalensis*. Most of the study that was analyzed found that the most common vector used was *Aedes aegypti*, *Culex quinquefasciatus*, and *Anopheles stephensi*. The articles were mostly published between 2014-2021, and the other two were published around 2010 to 2012. After carefully reading the articles, the researchers observed that most of the specimens were bought or came from Asia, specifically India. The significant findings from the studies were tabulated, summarized, and are briefly discussed in Table I.

No.	References	Study Area	Study Design	<i>Ficus</i> Plant/s Used	Vector/s	Findings
1	Bekoe (2015)	Ghana	Experimental	<i>Ficus exasperata</i>	-	Only cardiac glycosides and saponins were found in

						<i>Ficus exasperata</i> leaves. The phytochemical identified in the leaves of <i>Ficus exasperata</i> indicate that it has the potential to be a source of plant constituents that may supply innovative treatments.
2	Esmaili et. al (2021)	Iran	Experimental	<i>Ficus glomerata</i>	<i>Culex quinquefasciatus</i> , <i>Culex tritaeniorhynchus</i> , <i>Aedes aegypti</i> , <i>Culex pusillus</i> , <i>Anopheles stephensi</i> , <i>Culex pipiens</i> , <i>Ochlerotatus caspius</i> , & <i>Anopheles culicifacies</i>	Polymeric nanoparticles are better for larvicides, nanoemulsions are better for adulticides, and lipid nanocarriers are better for repellents.
3	Govindarajan (2010)	India	Experimental	<i>Ficus benghalensis</i>	<i>Culex quinquefasciatus</i> , <i>Aedes aegypti</i> , <i>Anopheles stephensi</i>	<i>Ficus benghalensis</i> extracts are effective in controlling <i>Culex quinquefasciatus</i> , <i>Anopheles stephensi</i> , and <i>Aedes aegypti</i> mosquito larvae.
4	Heror et.al (2020)	India	Experimental	<i>Ficus glomerata</i>	-	The steroidal compound like <i>Ficus glomerata</i> steroidal compound (FGS) was found to be more immunopotent than all constituents alkaloid, flavonoid and tannins. Therefore, this steroidal compound can be linked to the immunomodulatory property of the plants.
5	Idowu et.al (2021)	Lagos, Nigeria	Experimental	<i>Ficus exasperata</i> and <i>Moringa oleifera</i>	<i>Culex quinquefasciatus</i> , <i>Anopheles stephensi</i> , and <i>Aedes aegypti</i> .	On both laboratory and field collected mosquitoes, the efficiency of <i>Moringa oleifera</i> nanoparticles was greater at lower concentrations than

						that of <i>Ficus exasperata</i> . Factors such as pesticide resistance in the field mosquito population seem to have no influence on the effectiveness of the two extracts, since mortality increased with increasing exposure duration. This demonstrates the nanoparticles' potential for application in an integrated strategy to combating mosquito vectors.
6	Rahman (2018)	India	Experimental	<i>Ficus religiosa</i>	-	The biological production of silver nanoparticles using <i>Ficus religiosa</i> leaf extract is an environmentally safe, straightforward, and easy technique to synthesize nanoparticles. This study shows that the <i>Ficus religiosa</i> plant leaf extract may be utilized to successfully synthesize silver nanoparticles.
7	Recuenco et.al. (2020)	Philippines		<i>Ficus ulmifolia</i> , <i>Ficus pseudopalma</i> , <i>Mangifera altissima</i> , <i>Antidesma bunius</i> , <i>Garcinia binucao</i> , <i>Artocarpus altilis</i> , <i>Citrus hystrix</i> , <i>Canarium ovatum</i> , <i>Rubus rosifolius</i>	<i>Escherichia coli</i> , <i>Staphylococcus aureus</i>	Phytochemical screening showed positive results for phenolics, flavonoids, and tannins. The TPC results for the unripe <i>M. altissima</i> was within the range report and the TPC for the ripe <i>A. bunius</i> was close to the reported levels of the ripe fruit and lastly the TPC of the pulp and juice of ripe <i>C. hystrix</i> may be higher compared to the reported <i>C. hystrix</i> juice

8	Soni et. al. (2020)	India	Experimental	<i>Ficus religiosa</i>	<i>Anopheles stephensi</i>	Probit analysis was used to determine larvicidal mortality after 24 and 48 hours. The well diffusion method was used to assess antibacterial activity. The nanoparticles that were synthesized had an uneven form and varied in size.
9	Suriyakala et. al (2022)	India	Experimental	<i>Ficus religiosa</i>	Mice Model	Phenolics, alkaloids, flavonoids, steroids, and reducing sugar are all present in both fresh and dry leaf extracts. Only dried leaf extract included saponins, coumarins, tannins, and quinones. Furthermore, as compared to fresh leaf extract, dry leaf extract has a higher level of total phenolics and vitamin C (p0.05), although fresh leaf extract has a higher level of flavonoids and steroids.
10	Velayutham et. al. (2013)	India	Experimental	<i>Ficus racemosa</i>	<i>Culex quinquefasciatus</i> and <i>Culex gelidus</i> fourth instar larvae	The larvicidal activity showed that synthesized AgNPs had the maximum mortality against <i>Culex quinquefasciatus</i> and <i>Culex gelidus</i> larvae.

Table I. Characteristics of Included Studies.

C. Phytochemicals Present in Ficus Plants

Phytochemicals/secondary metabolites are the bioactive components of plants having a tremendous value in the pharmacological and therapeutic areas. The genus *Ficus* comprises a range of phytochemicals, including phenolics, polyphenols, flavonoids, tannins, anthocyanins, coumarins, volatile components, glycosides, saponins, carotenoids, alkaloids, triterpenoids, and vitamins. Generally, these phytochemical substances have health-enhancing benefits in humans due to their significant antioxidant capability. However, through this paper, another potential use of phytochemicals were discovered and have been discussed.

Chromatography and mass spectrometry are the methods often used to identify plant metabolites. According to Ali et.al (2021), plant-derived secondary metabolites gas chromatography and liquid chromatography-based analysis are commonly employed, while according to Hu et.al (2013), mass spectrometry (MS) is a rapid and sensitive tool for the analysis of metabolites from biological samples.

Upon data collection, the researchers identified five *Ficus* plants that met the requirements which can be used for this review paper. The first one is *Ficus benghalensis* containing important phytochemicals/secondary metabolites, which are saponins, flavonoids, tannins, and alkaloids. These were identified via different methods such as DPPH scavenging assay, Iron chelating assay, Folin-Ciocalteu reagent method, Aluminum chloride method, HPTLC and, HPLC. Another *Ficus* plant is the *Ficus exasperata*, which has cardiac glycosides and saponins as its phytochemicals and were identified by the Rotary evaporator method. The *Ficus glomerata* contains tannins and steroids that TLC and Column chromatography identify. The *Ficus racemosa* with tannins, B-sitosterol, stigmasterol as phytochemicals and were identified with UV-vis spectroscopy, XRD, SEM and, FTIR. And the *Ficus religiosa* with phytochemicals of phenolics, alkaloids, flavonoids, and steroids identified with UPLC-QqQ-MS system and Masslynx MS. Based on the available literature, flavonoid was one of the most commonly reported or projected chemicals responsible for generating silver nanoparticles in the green synthesis method. Table II provides the summary of the phytochemicals identification for each plant and their corresponding methods.

Ficus Species	Phytochemicals/Secondary Metabolites	Method/s	References
<i>Ficus benghalensis</i>	Saponins, Flavonoids, Tannins, Alkaloids	DPPH scavenging assay, Iron chelating assay, Folin-Ciocalteu reagent method, Aluminium chloride method, HPTLC, HPLC	Rao et al. (2014)
<i>Ficus exasperata</i>	Cardiac glycosides, Saponins	Rotary Evaporator	Bekoe (2015)
<i>Ficus glomerata</i>	Tannins, Steroids	TLC, Column chromatography	Heroor (2020)
<i>Ficus racemosa</i>	Tannins, B-sitosterol, Stigmasterol	UV-vis spectroscopy, XRD, SEM, FTIR	Velayutham et al. (2013)
<i>Ficus religiosa</i>	Phenolics, Alkaloids, Flavonoids, Steroids	UPLC- QqQ-MS system, MassLynx MS	Suriyakalaa et al. (2022)

Table II. Phytochemicals Present in Ficus Plants.

D. Syntheses of Silver Nanoparticles using Ficus Plants Extracts

According to Chung et.al (2016), green synthesized nanoparticles have gained increased attention because of consumer interest in environmentally friendly goods. Additionally, the synthesis of nanoparticles using plants has several benefits, including cleaner solvents, a reduction in hazardous chemicals, softer reaction conditions, practicality, and adaptation to medical, surgical, and pharmaceutical applications.

The synthesis of silver nanoparticles has a protocol that is generally followed by scientists and researchers. According to Ahmed et.al (2016), the procedure will start with the plant's leaves being removed and subsequently cleaned with distilled water. Immediately after washing, the leaves are squeezed using a domestic blender to create a juice. Afterward, using filter paper, the fluid is then filtered to produce an extract. The extract was then placed in a container, and silver nitrate was added. When the silver nitrate was added, the solution soon turned yellow, indicating the formation of silver nanoparticles. Figure I depicts the detailed process of the general protocol in synthesizing silver nanoparticles.

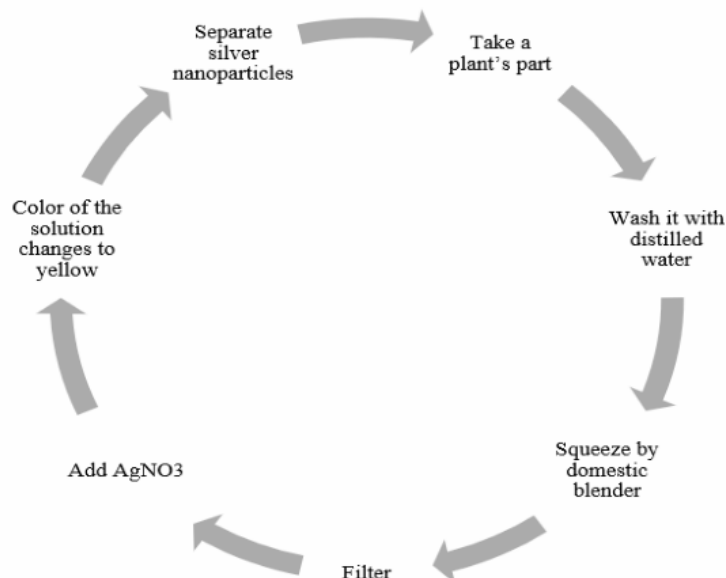


Figure 1. General Protocol on Synthesizing Silver Nanoparticles from Plant Extracts. Retrieved from “A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise” by Ahmed et.al (2016).

In this review paper, green synthesis of the silver nanoparticles derived from some *Ficus* spp. are also discussed below. Table II shows the characterization of the silver nanoparticles produced from these plant extracts.

Taken from the method done by Govindarajan (2010), the leaf of *F. benghalensis* was carefully cleaned with deionized water prior to the synthesis of silver nanoparticles. The *Ficus benghalensis* leaf underwent washing, drying, and was cut into small pieces, which then combined with deionized water and heated for 5 minutes before removing excess. 103 M aqueous solution of silver nitrate (AgNO_3) was also used to reduce silver ions. According to Govindarajan (2010), when the extract of *F. benghalensis* is combined with an aqueous solution of silver ion complex, the color changes from white to yellowish brown, which indicates the creation of silver nanoparticles owing to surface plasmon resonance excitation. The size and shape of the silver nanoparticles, however, are not stated in the said article.

As Idowu et al. (2021) stated in their recent study, *Ficus exasperata* extracts were prepared at Herbarium, Department of Botany, University of Lagos, Lagos, Nigeria. 40g of *F. exasperata* leaves were washed thoroughly in 400mL distilled water for 5 minutes before boiling for 15 minutes, cooled, and filtered with Whatman-1 filter paper, and kept refrigerated until further use. After that, to have a solution of 0.05M silver nitrate solution that will be used to produce a brownish powder of silver nanoparticles, 300mL of distilled water was added to 1.54g of silver nitrate, then stirred with a magnetic stirrer for 5 minutes while adding 20mL of plant extracts, and was observed for a color change. The initial pale yellow color will be changed to dark brown after 72 hours and later on to be subjected to centrifuge at 400rpm for 20 mins. Lastly, the supernatant was discarded, and the residue was oven-dried at 70 °C to have brownish powder silver nanoparticles. Through the use of SEM micrographs, the size of the synthesized particles was found to be around 500 nm. However, the shape of these was not clearly stated.

In a review paper on the use of plants as an essential oil that is based on nanoformulation to serve as a larvicide. Esmaili et al. (2011) stated that nanoemulsion physical stability is high though, during the larvicidal test it greatly decreases which leads to the short-term durability of its larvicidal effect. Based on their study, with the numerous articles being published they discovered that herbal extracts are being used as a reducing agent to synthesize the silver nanoparticles from AgNO₃ or AgCl. Silver nanoparticles do not use reducing agents that are toxic plus, can easily interact with functional groups of chemicals. However, in the test conducted the chemically synthesized nanoparticles that have a particle size of 30 nm only showed to have a 20% at 100 ppm larvicidal effect. In the research study, the ethanol extract of the *Ficus glomerata* plant was added in the nanoemulsion of neem oil (NON) for the crystallization emulsion.

Based on the article of Velayutham et.al., (2013), the synthesis of silver, 250 mL distilled water was added to 2.5 g of *F. racemosa* bark powder and boiled for 5 minutes then filtered. The filtrate was incubated at room temperature with an aqueous 1 mM silver nitrate solution. A brown solution was obtained by reducing an 80 mL aqueous solution of 1 mM AgNO₃ with 20 mL bark extract at room temperature for 10 minutes, showing the formation of AgNPs. The produced silver nanoparticles were cylindrical, uniform, rod-shaped, and had an average size of 250.60 nm, which were identified using SEM micrographs.

Referring to the method done by Rahman & Prasanna (2018), a 1 gram of powdered leaves extract of *Ficus religiosa* was added to the 10 ml of methanol or a 1:10 ratio. It was kept in a shaker incubator for 12 hours and was stored at 4°C in the refrigerator. The extract was then added to the AgNO₃ solution and a change of color was detected after 24 hours. Due to the surface plasmon resonance vibration, the color changes from pale yellow to dark brown throughout incubation, signifying the synthesis of silver nanoparticles. The silver nanoparticles have the shape of spherical measuring 70.29-84.93 nm.

Ficus Species	Plant Part Used	Size	Shape	Qualitative Findings	References
<i>Ficus benghalensis</i>	Leaves	-	-	Color changes from white to yellowish brown	Govindarajan (2010)
<i>Ficus exasperata</i>	Leaves	500 nm	-	Color changes from pale yellow color to dark brown	Idowu et.al (2021)
<i>Ficus glomerata</i>	Leaves	30 nm	Spherical	Formation of nanocrystals	Esmaili et al. (2011)
<i>Ficus racemosa</i>	Bark	250.60 nm	Cylindrical, Uniform and Rod	Color changes into a brown solution	Velayutham et.al (2013)
<i>Ficus religiosa</i>	Leaves	70.29-84.93 nm	Spherical	Color changes from pale yellow to dark brown	Soni & Dhiman (2020)

Table III. Characterization of Silver Nanoparticles Derived From *Ficus* Species.

E. Larvicidal Activity of Extracted Silver Nanoparticles Against *Aedes aegypti*

The WHO's general larvicidal bioassay approach involved batches of 10 to 25 third or fourth instar larvae being put to small disposable test cups holding 200 mL of water each. Starting with the

lowest concentration, the required volume of dilution was added to 200mL water in the cups to reach the desired target dosage (concentration ranging from 25 to 200 ppm). Using Probit regression analysis and the statistical software program, the lethal concentrations that killed 50% and 90% of mosquito larvae (LC₅₀ and LC₉₀) were identified (SPSS). The concentration of a substance in the air that, based on laboratory testing, is estimated to kill half of a set of test animals when given as a single exposure.

The methanolic extract of *F. benghalensis* showed highest larvicidal activity against *Cx. tritaeniorhynchus* and *An. subpictus* which shows 60 to 90% concentration. Meanwhile, for *Ficus exasperata*, a mortality of 23% -93% were recorded respectively. In *Ficus glomerata*, no larvae died in the observance in negative control while *Ficus racemosa* was found to have the highest mortality in synthesized Ag NPs against the larvae of *Cx. quinquefasciatus* and *Cx. gelidus* at the concentration of 25 mg/L. Lastly, *Ficus religiosa* has shown that the fourth instar has 100% mortality after the 24 hour exposure. Table III shows the final results on larvicidal activity of green-synthesized silver nanoparticles from *Ficus* spp. against *Aedes aegypti*.

To summarize the table, all of the journals that the researchers use are under the *Ficus* spp. For the instars which are the larvae, all journals use a 4th instar except for the *Ficus exasperata* while in exposure period are 24 hours except for the *Ficus glomerata*. In lethal concentration 50, the results show different concentrations in each *Ficus* spp ranging from 1 ppm to 80 ppm while in lethal concentration 90, only 3 out of 5 journals use it. The results show that in *Ficus benghalensis*, the lethal concentration 90 is at 169.58 ppm, *Ficus exasperata* is at 8.55 ppm and *Ficus racemosa* is at 64.99 ppm which indicates that there is a huge difference in the lethal concentration 90.

Plant Extract Used	Instars	LC ₅₀ (ppm)	LC ₉₀ (ppm)	Exposure Period	References
<i>Ficus benghalensis</i>	4th Instar	80.85 ppm	169.58 ppm	24 hr	Govindarajan (2011)
<i>Ficus exasperata</i>	Late 3rd Instar	1.51 ppm	8.55 ppm	24 hr	Idowu et.al (2021)
<i>Ficus glomerata</i>	4th Instar	20 ppm	-	48 hr	Esmaili et.al (2011)
<i>Ficus racemosa</i>	4th Instar	14.55 ppm	64.99 ppm	24 hr	Velayutham et.al (2013)
<i>Ficus religiosa</i>	4th Instar	25 ppm	-	24 hr	Soni & Dhiman (2020)

Table IV. Larvicidal Activity of Extracted Silver Nanoparticles From *Ficus* spp. Against *Aedes aegypti*.

DISCUSSION

The purpose of this study is to review the larvicidal activity of silver nanoparticles extracted from different *Ficus* spp. as they have the potential to be useful in pest management strategies that are integrated. Specifically this systematic review aims to help the general community and local workers have an idea on what are the possible plant alternatives to synthetic insecticides for killing larvae or adult mosquitoes, and gain knowledge for the future researchers which may also serve as their grounds for future references and background literature.

Insecticides sprayed on mosquito larvae habitats or indoors against adult mosquitoes are the most common methods of control. However, although insecticides were historically efficient in managing mosquito-borne diseases, their rising trends may reflect an increase in insecticide resistance or ineffectiveness in controlling disease transmission. Insecticide resistance has emerged in numerous *Aedes aegypti* mosquito populations around the world, and it has hampered control efforts and is a major public

health concern. Insecticide resistance mechanisms may include resistance to target-site and penetration. The excessive use of hazardous chemicals to control mosquitoes has also resulted in insecticide resistance. The mentioned mechanisms cause the mosquitoes, like *Aedes aegypti*, to become resistant to insecticides making them less effective in controlling the population. As a result, many studies have been searching for alternative ways such as using an extraction from a plant.

The mechanism of action of silver nanoparticles is defined by Idowu et al. (2021) as a breach of the larval membranes through the binding of the sulfur containing proteins or the phosphorus containing molecules that caused the denaturation of specific proteins. Whereas, Wehab et al. (2021) defined that the silver nanoparticles are able to form an ionic connection with bacterial cell impaired action of the thiol-group enzymes thus, provide an proton motive force that is elevated. Also, it has been stated that the capability of AgNP to activate the antibacterial properties is due to the electrostatic interaction in the bacterial surfaces. In other terms, the bacteria that is exposed in silver nanoparticles showed morphological abnormalities since it has been compromised as compared to bacteria that does not have exposure with the silver nanoparticles showed no alterations both physiologically and morphologically.

In the study of Velayutham, K., et. al. (2013), aqueous crude bark extracts and synthesized AgNPs from *Ficus racemosa* were found to be larvicidal; however, synthesized AgNPs at a concentration of 25 mg/L killed the most *Cx. quinquefasciatus* and *Cx. gelidus* larvae. The same result in the study of Rahuman et.al (2008), the separation and identification of tetracyclic triterpenes derivative from acetone extract of *F. racemosa* were guided by bioassays; gluanol acetate was isolated and identified as a new mosquito larvicidal compound, and it was quite potent against fourth instar larvae of *Aedes aegypti*, *Anopheles stephensis*, and *Cx. quinquefasciatus*. The current green synthesis demonstrates that *F. racemosa*, an environmentally friendly and renewable source, may be used as an effective reducing agent in the production of AgNPs. Rahman & Prasanna (2018) reveal that the leaf extract of the *Ficus religiosa* plant may be used to synthesize silver nanoparticles. The maximum generation of silver nanoparticles was seen at a concentration of 40 ul. The production of silver nanoparticles decreases as the concentration of plant extract decreases. This biological metal reduction would be a benefit to the development of a clean, non-toxic, and environmentally acceptable "green approach" to producing metal nanoparticles, utilizing species ranging from higher plants. Idowu, E. T. et al. (2021) have reported the aqueous extracts of *Moringa oleifera* and *Ficus exasperata* were used to synthesize AgNPs. On both laboratory and field-collected mosquitoes, *Moringa oleifera* nanoparticles were more effective at lower concentrations than *Ficus exasperata*. Insecticide resistance in the field mosquito population appears to have no effect on the efficacy of the two extracts since mortality rose as exposure time increased. This demonstrates the nanoparticles' potential for usage as part of an integrated mosquito vector control strategy. It was believed that phytochemicals are known to have extended efficacy and usually have more than a "contact and kill" effect on insects; they have a variety of effects on mosquitos, including reducing their longevity, exposing them to harsh environments and predation, and making resistance unlikely (Vatandoost & Vaziri; Idowu et al., 2021).

Resources are one of the main limitations of the study. Out of the 62 articles identified, only 12 were included in the study. The resources were limited to credible database and screened studies that are mainly peer-reviewed, with college student respondents, and those that tackled silver nanoparticles, *Ficus spp*, and insecticidal resistance. More specifically, it is pinned down to the silver nanoparticles derived from *Ficus spp*. Additionally, the chosen literature studies also cover larvicidal activity of the silver nanoparticles, green synthesized silver nanoparticles and *Aedes aegypti*. These 12 articles are all experimental and cross-sectional studies. With regards to the materials to be used, only limited studies tackled testing the specimen *Ficus spp* and the test were conducted using spectrophotometry alone.

CONCLUSION AND RECOMMENDATIONS

Silver nanoparticles (AgNPs) are known for having benefits of being cost-effective, energy-efficient, and environmentally-friendly which results in lesser pollution and safer outputs. Silver nanoparticles derived from the extracts of *Ficus* species against *Aedes aegypti* can be a feasible option that outperforms typical solvent extracts in terms of larvicidal activity and can be an effective alternative

for controlling mosquitoes. Different natural secondary metabolites were found in some *Ficus* plant extracts which function as agents for reduction and stabilization in the creation of silver nanoparticles. Furthermore, silver nanoparticles produced by these plants are similarly stable because of the presence of natural capping agents such as proteins, resulting in prevention of the particle aggregation. The larvicidal activity of the green-synthesized silver nanoparticles has also been enhanced due to the natural cytotoxicity of the *Ficus* plant extracts.

Unfortunately, the mentioned studies above regarding the larvicidal activity of silver nanoparticles from *Ficus* plant extracts against *Aedes aegypti* are still insufficient. Therefore, the researchers recommend more studies on this topic to further explore the potential uses of the *Ficus* species as well as to have more alternative strategies to control dengue outbreaks.

ACKNOWLEDGMENTS

The researchers would like to thank the following people who selflessly shared their time and resources to make this review paper possible. We would also like to express our gratitude to our research adviser, Dr. Maribel Ganeb, for the support and advice to have a much better research paper and for giving us your best in teaching us the lessons despite the hard times in the study. The researcher would like to extend a special acknowledgement to Kristina Maria Petalcorin, a lecture professor, and we also thank Earl Adrienne Cano, a laboratory professor. The researchers could not explain how grateful we are to these amazing people who became part of us and had given strength, support, encouragement, and motivated us to work better on this research. Lastly, we would like to thank God for guiding us every day in the face of the people around us, such as our families, peers, and friends. We are thankful for the opportunities God gave us each day to live in his love.

AUTHORS' CONTRIBUTIONS

All of the authors worked together to complete this paper. Asi, A.A.T. led the group and organized the ideas that must be discussed in this paper. She also constructed the abstract and conclusion. Asi, A.A.T., Bagnes, K.J.C., Carbonel, J.C., Cayetano, M.M.M, Chua, O.J.G., Cruz, C.J.S., Mariano, A.T.R., and Yanuaria, D.K.N. contributed to the introduction, results, and discussion. Ganeb, M.D. was the one who analyzed the paper in order to further improve the flow of the review paper. The final version of the paper has been read and approved by all authors.

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