Utilization of Technology Enhanced, Research-Based Instruction, Assessment and Development (TRIAD) Scale-Up Model in the Teaching of Senior High School Mathematics

Jaydeen L. Lopez(✉)

Department of Education, Alangilan Senior High School, Batangas, Philippines
jaydeen.legaspi@deped.gov.ph

Abstract. Mathematics is a motivational gateway to success which moves the society inexorably into its modern notion. This study determined the utilization of TRIAD Scale-Up Model in the teaching of senior high school mathematics as well as the problems met in using the model. The descriptive method of research was adopted with the aid of questionnaires and interview as the primary tool in gathering data. Seventy-seven senior high school mathematics teachers served as the respondents of the study. In choosing the school per area, the study used purposive sampling. Based on the findings, respondents seek professional advancement continuously in the pursuit of accurate and adequate knowledge in mathematics to a great extent. This also accentuated that the extent of utilization of senior high school mathematics teachers in the TRIAD Scale-Up Model differed significantly when they are grouped according to the fields of specialization and research productivity. Nevertheless, the major issue that should be properly addressed was the limitation on access to software resources. As an output, the researcher attempted to capture the manifestation of an effective teaching by designing a teaching guide and module in General Mathematics that can be used by senior high school mathematics teachers.

Keywords: assessment · mathematics · professional development · research-based instruction · technology

1 Introduction

Mathematics reveals hidden patterns of abstraction that help human to understand the world around them. This entails the creation of mathematical contexts that can serve as a potential platform for real-world applications that align with the interests and goals of students [1]. By serving as a source of motivation, mathematics can serve as a gateway to achievement [2], driving society towards state-of-the-art understanding of mathematics that is not limited to predetermined methods and techniques.

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However, many students in traditional content-focused mathematics curriculum perceive mathematics as a collection of strict rules that produce accurate outcomes, and experience anxiety and difficulty when it comes to applying their knowledge in different contexts, also known as transfer [3]. The motivation to learn relies on the capacity to stimulate students to reflect on the significance of concepts by manipulating symbols, which necessitates proficiency in procedures and critical thinking. This is to avoid having to persuade doubtful students about the practicality and elegance of mathematics.

Recently, Phillipines' Department of Education (DepEd) introduced Senior High School Mathematics through Republic Act No. 10533, also known as the Enhanced Basic Education Act of 2013 or K to 12 Curriculum, in response to the learners' need for comprehensive and critical thinking-focused mathematics education. The program has two core subjects, General Mathematics and Statistics and Probability, which all Senior High School students are required to take regardless of their chosen strand. The curriculum also includes specialized mathematics subjects that vary depending on the student's chosen strand. According to the K to 12 Curriculum Guide, each subject must be taught for eighty hours per semester, with specific content, performance standards, and competencies outlined for each session.

The primary objective of Senior High School Mathematics in the Philippines is to cultivate critical and analytical thinking abilities in all students. These skills include problem-solving, mathematical communication, logical reasoning, and establishing mathematical connections. The aim is to attain this objective by imparting comprehensive mathematical knowledge, enhancing cognitive abilities, and instilling desirable cognitive values in students of all backgrounds and situations. However, this aspiration can only be accomplished with the aid of dedicated and proficient teachers.

Senior high school teachers, according DepEd Order No. 42 series of 2017 [4], should recognize the significance of mastering content knowledge and its interconnection within and between subjects, along with a critical comprehension of the application of teaching and learning theories and principles. They implement developmentally appropriate and meaningful teaching methods that are founded on up-to-date research and content knowledge. Additionally, they employ a variety of resources and offer intellectually stimulating and challenging activities to encourage constructive classroom interactions that aim for high learning standards. In relation to student diversity, they utilize the students' characteristics and experiences as inputs for designing and planning learning opportunities.

Regarding student assessment, a range of assessment methods and techniques are utilized to monitor, evaluate, document, and report learners' needs, progress and achievement. The assessment information is employed in several ways to inform and improve the teaching and learning process. However, personal and professional reflection and learning are highly regarded to improve their teaching practice, and they take accountability for their personal and professional development for lifelong learning.

Along with the DepEd Order No. 36, s. 2013 [5], teachers' role of in nation building is critical. They are instrumental in developing students who are well-rounded, possess 21st Century skills, and can contribute to the country's growth and progress. To achieve this goal, teachers must adopt appropriate pedagogical methods to explain complex mathematical concepts effectively. Therefore, it is essential to have teaching strategies and techniques that are grounded in underlying assumptions to enhance learning in specific contexts. By doing so, teachers can implement developmentally appropriate teaching methods that cater to the individual differences among students. Sarama and Clements [6] introduced the Technology Enhanced, Research-based Instruction, Assessment, and Development (TRIAD) Scale-Up Model to teach mathematics, which addresses this need.

The TRIAD Scale-Up Model proposes that to successfully scale-up any educational intervention, it is important to focus on three key components: improving instruction through an empirically supported curriculum, promoting formative assessment, and supporting teachers with high-quality professional development. The model is grounded in research and employs technology to enhance its effectiveness. At the core of the model are research-based learning trajectories that consist of three elements: a goal, a developmental progression, and an instruction tailored for each level of that progression. The learning trajectories are designed to describe students' thinking and learning in a specific mathematical domain and provide a path through a set of instructional tasks that support their achievement of specific goals in that domain.

It is the goal of DepEd that its successful teachers possess a strong understanding of the content they teach, which they can then use to create effective learning objectives. They should also be able to choose the best teaching strategies and materials to achieve these objectives, make informed decisions based on formative assessment results, promote their students' holistic development, and maintain a professional and ethical approach in the conduct their work. DepEd recognizes that the quality of teaching greatly impacts the quality of learning, so it is crucial to hire and support good teachers. To foster a new culture of learning, teachers must embrace what they do not know, ask better questions, and continue learning incrementally and exponentially. Last but not least, teachers' attitudes to mathematics and the teaching of mathematics also matters, as it can greatly influence the environment where the mathematics is taught [7].

Hence, based on the foregoing discussions, the researcher was prompted to determine the extent of utilization of TRIAD Scale-Up Model of senior high school mathematics teachers in the Division of Batangas. This study hopes to provide an objective evaluation of the performance of senior high school math teachers through a research-made questionnaire applying the ten research-based guidelines of the model crafted by Clements and Sarama.

Aside from this, the teachers' responses of their extent of utilization of the TRIAD Scale-Up Model will relate to their profile to see if there will significant differences between their responses, in order to highlight which of the variables will gain impact on their utilization. Teachers also experience constraints in the utilization of TRIAD Scale-Up Model in teaching mathematics. To respond to the findings and conclusions of the study, the researcher attempted a teaching guide in General Mathematics to suffice the TRIAD Scale-Up Model instructional materials that can be used by the senior high school mathematics teachers.

The main purpose of this research study was to determine the utilization of Technology-Enhanced, Research-based Instruction, Assessment and Development

(TRIAD) Scale-up Model in the teaching of senior high school mathematics. Specifically, the study particularly sought answers to the following questions:

1. What is the profile of senior high school mathematics teachers in terms of:
   - academic rank;
   - highest educational attainment;
   - number of years in teaching mathematics;
   - field of specialization;
   - senior high school strand handled;
   - attendance in seminar or training; and
   - research productivity?
2. To what extent do the senior high school mathematics teachers utilize the TRIAD Scale-up Model in teaching mathematics?
3. Is there any significant difference on the extent of utilization of TRIAD Scale-up Model of mathematics teachers when they are grouped according to their profile?
4. What are the problems met by the mathematics teachers in the use of TRIAD Scale-up Model?
5. Based on the analysis, what teaching guide using TRIAD Scale-up model may be prepared?

2 Methods

This study employed the quantitative – descriptive analysis [8] to determine the utilization of TRIAD Scale-Up model in the teaching of senior high school mathematics. The respondents of this study were the public senior high school mathematics teachers in the Division of Batangas Province. Out of 95 senior high school mathematics teachers, only 77 of them participated and have accomplished the questionnaire completely.

In choosing the schools per area, the study used purposive sampling [9]. The criteria for choosing the schools are those that have laboratories well-equipped for the purpose of increasing practical applications, demonstrations and experimentation, in this case is Information and Communication Technology (ICT) rooms. This was a main point of consideration since not all schools in Batangas had laboratories and ICT rooms.

2.1 Data Gathering Instruments

The study used questionnaire and interview as data gathering instrument. To construct a questionnaire that was utilized for the collection of information, the researcher made the first draft of the questionnaire that was prepared and was shown to the adviser for corrections, comments and suggestions. The questions were also based on the ten research guidelines of TRIAD Scale-Up Model according to Clements and Sarama [6] and anchored on the objectives of the study. Moreover, the questionnaire was composed of a checklist about the profile of the respondents followed by the items on the utilization of senior high school mathematics teachers of the TRIAD Scale-Up Model in teaching mathematics and the last part was about the problems met by the senior high school mathematics teachers in the utilization of the model.

Subsequently, the validated questionnaire was later tried to 20 senior high school mathematics teachers in the Division of Batangas City who were not included in the study. This was done to determine the internal consistency of the instrument. It yielded a Cronbach's alpha coefficient of 0.911. Since the result was greater than 0.7, this was an implication of good internal consistency and reliable results obtained from the questionnaire. The process was done systematically and accurately until the final copy had been furnished.

To strengthen the results and discussion of the study, the researcher also interviewed ten mathematics teachers who can give additional information about the questions presented in the interview sheet. The respondents of the study were ten senior high school mathematics teachers. The interview guide was composed of eight essential questions to deduce the insights and experiences of senior high school mathematics teachers on how they utilized the TRIAD Scale-Up Model and to determine the topics in General Mathematics that should be addressed by the teaching guide.

3 Result and Discussion

3.1 Profile of Senior High School Mathematics Teachers

Based on the findings of the study, majority of teachers in the Division of Batangas Province were Teacher II, Bachelor's degree, barely five years and below in the profession, had mathematics as their field of specialization, handled Accountancy, Business and Management (ABM) strand, fall under very active and active participation in seminars and trainings for the last 5 years and not productively engaged in research.

Respondents sought professional advancement continuously in the pursuit of accurate and adequate knowledge in mathematics to a great extent. This tops the list and has a computed weighted mean of 3.56. In this concern, it is revealed that engaging in professional learning is the primary vehicle for ensuring the ongoing effectiveness in promoting the learning of the students. This conforms the statement of Mizell [10] that professional development yields three levels of results, educators learn new knowledge and skills because of their participation (Table 1).

3.2 Extent of Teachers' Utilization of the TRIAD Scale-Up Model in Teaching Mathematics

As presented in the table, respondents seek professional advancement continuously in the pursuit of accurate and adequate knowledge in mathematics to a great extent. This tops the list and has a computed weighted mean of 3.56. In this concern, it is revealed that engaging in professional learning is the primary vehicle for ensuring the ongoing effectiveness in promoting the learning of the students. As a professional community, teachers are becoming more conscious of the significance of continuous professional development and recognize the value of being lifelong learners, keeping themselves updated with the latest advancements and insights in their respective fields. This aligns with Mizell's [10] assertion that professional development leads to three levels of outcomes, namely educators obtaining new knowledge and skills through their participation, applying what they learn to improve their teaching, and improve their students' learning and achievement (Table 2).

Table 1. Profile of the Respondents

Variable	Category	n	%
Academic Rank	Teacher I	8	10.40
	Teacher II	53	68.80
	Teacher III	15	19.50
Highest Educational Attainment	Master Teacher	1	1.30
	Doctorate Degree	6	7.8
	Master's Degree	17	22.1
	Bachelor's Degree	54	70.1
Years of Teaching Mathematics	5 and below	38	49.3
	6 to 10	19	24.7
	11 to 15	9	11.7
	16 to 20	8	10.4
	21 and above	3	3.9
Field of Specialization	Mathematics	63	81.8
	Non-Mathematics	14	18.2
Senior High School Strand Handled	ABM	32	41.60
	GAs	3	3.90
	STEM	20	26.00
	TECHVOC	13	16.90
	HUMSS	9	11.70
Participation to Seminars/Trainings	Very Active (11 and above)	27	35.10
	Active (6 to 10)	27	35.10
	Not Active (5 and below)	23	29.90
Research Productivity	Very Productive	7	9.09
	Productive	3	3.90
	Moderately Productive	16	20.78
	Not Productive	51	66.23

3.3 Differences on the Extent of Utilization of TRIAD Scale-Up Model of when Teachers Are Grouped According to Their Profile Variables

The findings indicate that there is a significant difference in the extent of utilization when they are grouped according to their fields of specialization and research productivity (Table 3).

After applying Scheffe's test of pair-wise comparison, the p-value of 0.045 indicates that the null hypothesis is rejected. This means that there is a significant difference between the extent of utilization of TRIAD Scale-up Model of senior high school mathematics teachers who are very productive in research and those that are not productive. The mean difference indicates that SHS math teachers who are very productive in research are more likely to have the greatest extent of utilization of TRIAD Scale-up Model. This result can be attributed to the fact that research plays an important role in the utilization of TRIAD Scale-up Model (Table 4).

Table 2. Extent of Teacher Utilization of the TRIAD Scale-Up Model in Teaching Mathematics

Items	WM	VI
1. Seeks professional advancement continuously in the pursuit of accurate and adequate knowledge in mathematics.	3.56	GE
2. Improves students' critical thinking through learning trajectories' developmental progressions and their pedagogical applications in formative assessment.	3.55	GE
3. Focuses on mastery of content knowledge and best practices of school.	3.53	GE
4. Initiates fairness through target students, allocation of resources and use of curriculum and instructional strategies to accomplish goals and objectives.	3.45	ME
5. Places learning path the core of wide range of strategies of teaching and learning process.	3.40	ME
6. Provides continuous and adaptive support over an extended period of time.	3.39	ME
7. Enhances the students' ICT skills by engaging them to online mathematics activities.	3.35	ME
8. Gives constructive criticisms and uses appropriate teaching techniques and instructional aids.	3.34	ME
9. Stresses meaningful conceptualization, emphasizing the students' own knowledge of the world and his learning environment.	3.34	ME
10. Exhibits substantial amount of reflection on pedagogy, classroom norms and identification of self and how others identify you.	3.32	ME
11. Uncovers, interprets, and analyzes students' learning of mathematics as well as their notions, beliefs and attitudes towards math.	3.32	ME
12. Involves and promotes a creative climate which inspires colleagues to think "beyond the box".	3.31	ME
13. Develops knowledge and beliefs that the curriculum is appropriate, and its goals are valued and attainable.	3.31	ME
14. Emphasizes connections between shared visions, goals and societal need to foster new ideas towards innovations.	3.30	ME
15. Uses appropriate instructional materials including ICT to engage students in a meaningful exploration, discovery and hands-on activities.	3.30	ME
16. Acquires the skills of analytical, critical and focused method of teaching mathematics.	3.30	ME
17. Thinks possible misconceptions that may occur during instruction and correct students for these misconceptions.	3.30	ME
18. Maintains frequent, repeated communication, assessment, and follow-through efforts for continuous improvement.	3.26	ME
19. Collaborates with colleagues in the conduct and application of research focuses on enriching knowledge of content and pedagogy.	3.25	ME

(*continued*)

Table 2. (*continued*)

Items	WM	VI
20. Employs different techniques and instructional strategies such as hands-on learning.	3.25	ME
21. Conducts in-depth studies or researches on teaching-learning innovations making it as high priority.	3.23	ME
22. Provides intrinsic and extrinsic motivations that translate constructive thinking into tangible changes.	3.23	ME
23. Leads colleagues in a professional discussion towards shared visions of planning and implementing strategies consistent with curriculum requirements.	3.22	ME
24. Shares effective techniques on differentiated, developmentally appropriate opportunities to address students' individual differences.	3.22	ME
25. Builds leadership by involving principal and encourages teachers to become teacher-researcher.	3.12	ME
COMPOSITE MEAN	**3.33**	**ME**

Legend: WM = Weighted Mean VI = Verbal Interpretation ME = Moderate Extent GE = Great Extent

Table 3. Difference on the Extent of Utilization of TRIAD Scale-up Model when Teachers are Grouped according to Profile Variables

Profile	F-value	p-value	Decision on Ho	Interpretation
Academic Rank	0.798	0.499	Failed to Reject	Not Significant
Highest Educational Attainment	1.177	0.314	Failed to Reject	Not Significant
Number of Years of Teaching	0.479	0.751	Failed to Reject	Not Significant
Fields of Specialization	3.871*	0.036	Reject	Significant
SHS Strand Handled	0.665	0.618	Failed to Reject	Not Significant
Participation to Seminars/Trainings	1.709	0.188	Failed to Reject	Not Significant
Research Productivity	2.942	0.043	Reject	Significant

*t-value

3.4 Problems Met by Senior High School Mathematics Teachers in the Use of TRIAD Scale-Up Model

As reflected in Table 5, teachers agreed that they experience limitation on access to software resources as reflected in the weighted mean of 3.14. This may be because not all school has internet connection or if they have, not all teachers have access to it. This conforms with the statement of Mayuga [11] that the use of world wide web was least utilized by teachers. Some public secondary schools have no internet connection; thus, it is difficult for the teachers to use the web.

Table 4. Pair-wise Comparison on the Extent of Utilization of TRIAD Scale-up Model when Teachers are Grouped according to their Research Productivity

Variable	Pair-wise	Mean Difference	p-value	Decision on Ho	Verbal Interpretation
Utilization of TRIAD Scale-up Model	Very Productive vs Not Productive	0.108	0.045	Reject	Significant

Table 5. Problems Met by Mathematics Teachers in the Use of TRIAD Scale-Up Model

Items	WM	VI
1. Limitation on access to software resources.	3.14	Agree
2. Limitation on access to hardware resources.	3.08	Agree
3. Inappropriate intervention on research-based strategies.	3.04	Agree
4.Time constraints between the work schedule and compliance to different requirements of graduate studies	2.99	Agree
5. Insufficient training in the use of ICT.	2.92	Agree
6. Dilemma in understanding the conceptual foundation of inquiry-oriented views of mathematics teaching and learning and current views of assessment.	2.78	Agree
7. Psychological barriers arising during observations by school heads which develops anxiety upon the evaluation of performance rather than learning from them.	2.77	Agree
8. Lack of necessary competencies in using technology.	2.74	Agree
9. Incompetent in the use of innovative pedagogical models.	2.69	Agree
10. Knowledge gained during professional training does not support the development of competencies needed.	2.64	Agree
11. Difficulty in monitoring student's learning.	2.61	Agree
COMPOSITE MEAN	**2.85**	**Agree**

Legend: WM = Weighted Mean VI = Verbal Interpretation

This idea had also transpired in the statement expressed by the interviewees that the only problem in 21st century classroom was the availability and the equitable access of each school to those innovative instructional materials including software resources.

3.5 Prepared Teaching Guide Using TRIAD Scale-Up Model

This teaching guide in General Mathematics comprises detailed manuals that offer a plethora of insights and suggestions on how to effectively manage classroom instruction. This resource is highly adaptable and can be tailored to suit diverse settings, meeting the specific requirements of educators. The guide provides clear guidance on instructional planning and ensures that the curriculum's core values align with the individual teaching beliefs and practices of the teachers.

4 Conclusion

In the light to the foregoing findings, the following conclusions are drawn.

- Majority of teachers in the Division of Batangas Province were Teacher II, have a bachelor's degree, barely five years and below in the profession, had mathematics as their field of specialization, handled Accountancy, Business and Management (ABM) strand, fall under very active and active participation in seminars and trainings for the last 5 years and not productively engage in research.
- Respondents seek professional advancement continuously in the pursuit of accurate and adequate knowledge in mathematics to a great extent.
- Extent of utilization of senior high school mathematics teachers in the TRIAD Scale-Up Model differed significantly when they are grouped according to the fields of specialization and research productivity.
- The major problem that should be properly addressed was the limitation on access to software resources.
- Teaching guide in General Mathematics was prepared for senior high school mathematics teachers as a reference in using TRIAD Scale-Up Model in the teaching learning process.

However, the study was limited on mathematics teachers in public senior high schools and did not include those in the junior high school. Also, the data content of this research study was limited to the result of the responses of senior high school mathematics teachers in the researcher's questionnaire. Likewise, several limiting factors of the study required considerations. It covered the accessibility, collaboration, honesty and willingness to participate of the respondents in answering the given questionnaires. Moreover, the results from the questionnaires became the basis of formulation of the conclusion and the recommendations of this research study.

The research study also delimited other instructional models. It delineated the emphasis on other teaching methodologies and approaches. The study did not cover the general profile of the schools in terms of science instruction and the division as a whole. It also delimited senior high school mathematics teachers' utilization of the model.

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