4S SELF-LEARNING MODULE AND ITS EFFECT ON STUDENTS' COGNITIVE FACETS OF UNDERSTANDING MATHEMATICS

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ABSTRACT: *The study was a quasi-experimental research conducted to investigate the effect of 4S(Sense-Making, Showing Representation, Solving with Explanation, and Synthesizing) Self-Learning module on students' cognitive facets of understanding mathematics. The participants of the study were the two intact classes of Grade 10 students enrolled during the 1st semester SY 2021-2022 at Tawantawan Integrated School. One section was assigned as a control group who was exposed to DepEd conventional self-learning module while the other one was an experimental group who was exposed to the 4S self-learning module. The performance of the students was measured using their test scores. To determine if the 4S self-learning module significantly affects the students' cognitive facets of understanding mathematics, the Analysis of Covariance Model (ANCOVA) was utilized at a 0.05 level of significance. Results revealed that the 4S self-learning module helped in the development of students' cognitive facets of understanding mathematics.*

Keywords: cognitive facets of understanding mathematics, 4S self-learning module, sense-making, synthesizing

1. INTRODUCTION

Understanding is the intent of teaching and learning mathematics. When we understand, we can remember, transfer knowledge to new contexts, apply concepts to novel situations, look at problems from varied perspectives, and explain in ways that make sense to others [1]. But many students are being left behind by an educational system that some people believe is in crisis [2]. Dunlosky et al [2] revealed that improving educational outcomes will require efforts on many fronts, but a central premise of this monograph is that one part of the solution involves helping students to better regulate their learning through the employment of effective learning techniques. Fisher and Frey [3] emphasized that checking for understanding is a vital step in the teaching and learning process. In fact, it is an element of a formative assessment system in which teachers should identify learning goals, provide students feedback and address learning gaps, especially on the students' errors and misconceptions.

The most recent results of the Program for International Student Assessment (PISA) revealed an alarming situation about Filipino students' performance in these mathematical capabilities [4]. The Program for International Student Assessment (PISA) by the Organization of Economic Cooperation and Development is meant to assess educational systems by measuring 15-year-old high school students' scholastic performance, especially on mathematics. Results revealed that Filipino students' scores in mathematics ranked 76th out of 77 participating countries [5]. The PISA 2018 mathematics framework is designed into some major sections. One of its major sections is "Defining Mathematical Literacy". It is a student's capacity to formulate, employ, explain, describe, predict and interpret mathematics in an exceeding sort of contexts [4]. The enumerated fundamental mathematical capabilities are mostly components of cognitive facets of understanding.

The result of the student's performance in the National Achievement Test (NAT) for fourth-year high school students is additionally alarming. It reveals that the national average is 58.6% passing rate [6]. The goal for the said test is a 75% Mean Percentage Score (MPS). Hence, the Department of Education (DepEd) acknowledged the immediate action of addressing issues and gaps in achieving the quality of basic education in the Philippines [7].

In this context, a teaching strategy to enhance students' cognitive facets of understanding is incredibly important. Sense-making should be always in every classroom where it can help students develop an understanding of a situation, context, or concept by associating it with existing prior knowledge [8], and it can even build a piece of evidence in order to resolve a gap or inconsistency in knowledge [9]. Koedinger et al [10] on their cognitive learning theories stated that when students are engaged in sense-making processes, it allows them to acquire a principled understanding of complex concepts. These explanations and studies of some authors highly suggested that sense-making can really help students learn and enhance their cognitive facets of understanding. If the student can translate any style of representation then they need better ability in accessing mathematical ideas [11]. Representation should be treated as an important element in supporting students' understanding of mathematical concepts and relationships [12]. Nordqvist [13] often points to the requirement for students to have interaction in additional cognitively demanding activities than simply solving tasks by applying given solution strategies. His study had shown that students could perform better in follow-up tests and algorithmic reasoning if they were engaged in creative mathematically founded reasoning to construct an answer. Lastly, synthesizing also can help enhance students' cognitive facets of understanding. A study by Lazic et al [14] revealed that paraphrasing, summarizing and synthesizing can help them write ideas on their own with correct grammar and that they can avoid plagiarism.

However, the world has been experiencing a pandemic that resulted in significant impacts on all humanity. Physical and social distancing are strictly implemented which results in the temporary closure of face-to-face classes that affect the continuing education of all students. Hence, the Department of Education (DepEd) of the Philippines issued a memorandum that aids to strengthen the implementation of the Basic Education Learning Continuity Plan in time of the pandemic [15]. Based on the results of the Learner Enrollment and Survey provided by DepEd as of July 2020, it has 7.2 million enrollees preferred to use printed modular distance learning, while 2 million enrollees preferred online learning for the school year 2020-2021 [16]. Thus, the Department of Education adopted the modular distance learning or often called the modular approach, and provided modules to the students. This module consists of self-directed learning activities that are self-instructional, self-paced, students directed, and the responsibility of learning is on the students. All examples have explanations given.

The learning modules prepared by DepEd were designed to prioritize the most essential competencies only to accommodate the current learning modality. Most of the references employed by teachers are textbooks. However, textbooks are different from self-learning modules. Textbooks were designed for students to learn with the guidance of the teacher. The Department of Education (DepEd) Region 10 issued a memorandum that teachers should employ a solution for the deteriorating academic performance of students, so interventions should be made to deal with learning gaps [17].

Since this present modality is modular and also the DepEd modules do not address the needs of the students, particularly on the cognitive facets of understanding mathematics, the researcher developed a 4S self-learning module and investigated its effects on students' cognitive facets of understanding mathematics (interpret, explain and apply) through sense-making, showing representation, solving with explanation, and synthesizing.

2. THEORETICAL FRAMEWORK

This study was framed on the 4S Learning Cycle Model by Bacabac and Lomibao [18]. The 4S stands for Sense-making, Showing representation, Solving with explanation, and Synthesizing. Based on this study, the 4S Learning Model enhanced students' comprehension. This present study wished to verify if the 4S Learning Model can enhance students' cognitive facets of understanding mathematics.

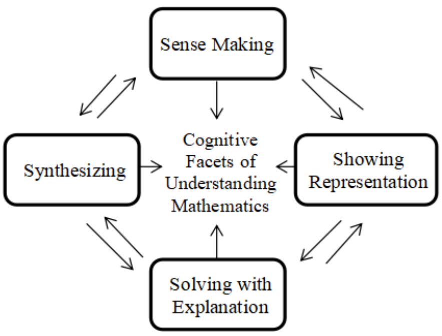

Figure 1. 4S Learning Cycle Model

According to Weick [19], sense-making means "the making of sense". He also added that it is a step on "structuring the unknown" wherein it gives motivation to the students [20]. It unlocks the students' several key learnings such as to comprehend, understand, explain, extrapolate, attribute, and even predict [21]. Teaching sense-making is classified as a leadership capability wherein it should use multiple teaching modes to bring this complex concept to life and create capacity in this domain [22]. Constructivism as cited by Fosnot [23] emphasizes the roles of the students in establishing understanding and making sense of the information. This teaching strategy is student-centered where students are involved in the process of knowledge construction rather than passive students.

Showing representation is the second component of 4S Learning Cycle Model. According to Bruner [24], the concept of representations was aligned to the concepts of constructivism of intellectual development theory patterned from the propositions of Piaget [25]. It has three modes of representation namely the concrete stage, pictorial stage and abstract stage. The concrete stage requires hands-on and manipulative activities related to learning wherein the actions were executed. Second, the pictorial stage is the next stage wherein it requires images or visuals to represent the concrete situation created in the first stage by drawing images, shapes, diagrams, and/or graphs on paper or to picture them in one's head. The third stage is the abstract stage also known as symbolic (language-based) and that is transferring the objects created in the second stage to a group of words or symbols. This last stage is important for it helps students organize the information captured in their minds by relating concepts together. The showing of representation will help in organizing and presentation of content, concepts, and module making. According to Burton-Jones and Grange [26], the showing of information must be clear and effective to obtain the maximum benefits from the learners.

The third component of the 4S Learning Cycle Model is solving with an explanation. Wichelt [27] revealed that communication is a vital skill in mathematics. However, during board activities, students could not explain the answers or solutions they have written on the board due to a lack of understanding. What they do most of the time is to read what they have written. Some have answers and wanted to participate but refused to do due to a lack of skills in explanation. Thus, to enhance cognitive facets of understanding, it is important that teachers require students to provide reasons for what they did and not just to relate the procedures that they used to solve problems.

The last component of 4S is synthesizing, the act of expressing the most important facts or ideas about something or someone in a short and clear form. It can increase students' understanding of concepts by giving them opportunities to see and think about the material in a different context and discuss them with their peers. Summarizing is also synthesizing that makes understanding clear to teachers [28]. The Law of Effect of Edward Thorndike is the belief that the pleasing after–effect strengthens the action that produced it [29].

3. OBJECTIVES OF THE STUDY

After validating the acceptability of the 4S Self-Learning Module, the researcher aimed to determine the effect of the 4S Self-Learning Module on students' cognitive facets of understanding mathematics. Specifically, the study sought to answer the question: How do the 4S self-learning module and DepEd self-learning module in Mathematics influence the students' cognitive facets of understanding mathematics?

4. METHODOLOGY

This study employed a quasi-experimental Pretest-Post Test Control Group designed to determine the effect of the 4S Self-Learning Module on students' cognitive facets of understanding mathematics. The experimental group was exposed to treatment that utilized the Self-learning Module incorporated with the 4S Learning Cycle Model while the control group was exposed to DepEd conventional self-learning module. The performances of the students were measured using their test scores. The study utilized the validated 34-item multiple-choice teacher-made test with 10 two-tiered constructed items. The study was conducted for a quarter (2 months).

The participants of the study were the two intact classes of Grade 10 students at Tawantawan Integrated School during the first quarter of SY 2021-2022. One section was randomly assigned as the experimental group and the other as the control group.

At the start of the study, a pretest was given to both control and experimental groups. Teacher-researcher was the one facilitating learning. Since face-to-face classes were suspended and there was a health protocol that needs to follow, students went to school by group and sometimes the researcher went personally to their houses or purok shed to administer the tests.

The modules were collected and returned by their parents in school every Monday and get another set of modules for the week. A daily monitoring sheet was provided attached to their modules. A monitoring sheet was answered by their parents/guardians. Also, aside from that, weekly monitoring was made by the researcher/teacher personally to their homes as a home visitation model. After the administration of modules, the posttest was followed with the same method how the pretest was administered.

To describe the students' cognitive facets of understanding mathematics level, the mean and standard deviation of the pretests and posttests were computed. To determine the influence of the two methods of teaching on students' cognitive facets of understanding mathematics, the one-way analysis of covariance (ANCOVA) was used, with the pretest as the covariate.

The K-12 descriptive level was adopted to interpret the students' cognitive facets of understanding mathematics level as shown in the rating scale below:

Table 1. Students' Cognitive Facets of Understanding Mathematics Rating Scale

Mean Score Range	Description/Interpretation
59.2 - 74	Outstanding (O)
51.8 - 59.19	Very Satisfactory (VS)
44.4 - 51.79	Satisfactory(S)
37 - 44.39	Fairly Satisfactory (FS)
Below 37	Did not meet the expectation

5. RESULTS AND DISCUSSIONS

The results of this study were presented in the following tables:

Table 2. Summary of the Mean and Standard Deviation

Type of Appraisal	Groups	n	Mean	SD	Level
Pretest	Control	31	22.206	7.106	Did not meet the expectation
	Experimental	34	22.194	7.756	Did not meet the expectation
Posttest	Control	31	35.882	9.111	Did not meet the expectation
	Experimental	34	45.548	8.197	Satisfactory

Table 2 shows the mean and standard deviation of the pretest and posttest results in their cognitive facets of understanding mathematics for both the control and experimental groups. Pretest scores revealed that both the control and experimental group were at the "Did not meet Expectation" level as indicated by the overall mean of 22.206 for the control group and 22.194 for the experimental group which resulted in a mean difference of 0.012. The very close association of the mean of the two groups indicates that they were comparable prior to the conduct of the study. It denotes that the student in both groups has almost the same level of cognitive facets of understanding mathematics prior to the experimentation period. Also, the standard deviation of the control group was 7.106, which is lower than that of the experimental group of 7.756. This indicates that the scores of students in the experimental group had a wider dispersion while the scores of students in the control group were closer to the mean.

The post-test scores revealed that the scores of the students in the control group who were taught using the conventional DepEd Self-Learning Modules (SLMs) through distance learning had significantly improved as indicated by the overall mean score of 35.882, yet it still remained at "Did not meet expectation" level. The significant improvement in the test scores of the students in the control group indicates that they are starting to get a grasp of the different mathematical lessons that were tackled in the DepEd SLMs during the experimentation period, however they were not able to reach a desirable level of mastery and understanding. A noticeable improvement was observed on the post-test scores of students in the experimental group who learned using the developed 4S Self-Learning Modules in Mathematics. The posttest score mean of 45.548 has reached the "Satisfactory" level. The experimental group scored a great higher than the control group by a mean difference of 9.666. This shows that students in the experimental group acquired a better understanding of the different mathematical concepts. These 4S SLMs were developed particularly to improve the students' cognitive facets of understanding mathematics such as interpret, explain and apply. A growing interest of students in the special features of the 4S Self-Learning Modules was also observed.

It can be further observed that the scores of students in the experimental group have a lower standard deviation which means that their scores are closer to the mean compared to the scores of students in the control group. In addition, the lower standard deviation in the experimental group means that the distribution of scores of the students was less dispersed than those of the control group. On the other hand, students in the experimental group were somehow homogeneous in performance in terms of their cognitive facets of understanding mathematics. To verify whether the difference was significant, ANCOVA was further used.

Table 3. One Way ANCOVA Summary for Students' Cognitive Facets of Understanding Mathematics

Source	SS	Df	MS	F-Value	p-Value
Adjusted Means	1517.05	1	1517.05	24.65	0.000006
Adjusted Error	3815.85	62	61.55		
Adjusted Total	5332.9	63			

*significant at p<0.05 alpha level

Table 3 shows the summary of the analysis of the covariance of pretest and posttest scores for students' cognitive facets of understanding the mathematics of the experimental and control groups. The analysis yielded a computed probability value of 0.000006 which is lesser than the 0.05 level of significance. This led to the non-acceptance of the null hypothesis. This means that there is sufficient evidence to conclude that the cognitive facets of understanding the mathematics of the students exposed to the 4S Self-Learning module are significantly higher than those exposed to the DepEd Self-Learning Module.

The content of 4S SLMs which focused on sense-making, showing representation, a solution with an explanation, and synthesizing has enhanced the students' cognitive facets of understanding mathematics. The sense-making process has helped the students understand the ideas and concepts in order to correctly identify, describe, explain, and apply them to a phenomenon [30]. They were able to recall the past lessons in order to apply and connect them to the preceding lesson. Also, showing a representation of the lesson helped the students visualize the problem. It is also believed that thru representation, students were able to collaborate, embodied learning that gets students out of their seats and moving as they create representations of texts [31]. Furthermore, an explanation given to the solution of the example problems are also very important for the students to understand well the examples such that in the succeeding problems in exercises and activities they can easily analyze and solve. Students were able to arrive at their answers to mathematics problems and they also knew how to explain and justify why they ended up at their answers, and communicate their understanding to others orally or thru writing [32]. Synthesizing also helped the students generate good decision making, analysis, and evaluation on their answers if it is correct or not [33].

6. CONCLUSION AND RECOMMENDATION

Based on the findings of the study, the 4S Self-Learning Module enhanced the students' cognitive facets of understanding mathematics. On this basis, teachers who are conducting modular distance learning to their students are encouraged to incorporate the 4S Learning Cycle Model on the self-learning modules to actively engage students in the learning process and subsequently improved their performance. The mathematics teachers may be given training on how to apply this strategy in the construction of students' self-learning modules. School administrators may support the implementation of the 4S Learning Cycle Model incorporated in the self-learning modules to be used for distance learning to significantly enhance the students' cognitive facets of understanding mathematics. Similar studies may be conducted in a more controlled environment where teachers can directly guide and observe the learning progress of students.

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