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4S Learning Cycle on Students' Mathematics Comprehension

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Abstract The study was a quasi-experimental research conducted to investigate the effect of 4S(**S**ense Making, **S**howing of Representation, **S**olution and Explanation, and **S**ummarization) Learning Cycle Model on students' mathematics comprehension. The participants of the study were the two intact classes of freshmen education students in College and Advanced Algebra course enrolled during the 1st semester SY 2019-2020 at the University of Science and Technology of Southern Philippines. One section was assigned as control group who was exposed to Polya Method of Problem Solving while the other one was experimental group who was exposed to 4S Learning Cycle Model. The performance of the students were measured using their test scores. To determine if the 4S Learning Cycle Model significantly affects the students' mathematics comprehension, the Analysis of Covariance Model (ANCOVA) was utilized at 0.05 level of significance. Results revealed that the 4S Learning Cycle Model helped in the development of students' mathematics comprehension.

Keywords: *mathematics comprehension, 4S Learning Cycle Model, sense making, summarization*

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1. Introduction

Mathematics is one of the oldest scientific disciplines yet, its applications are still very relevant for it is one of the basic foundation in understanding almost all phenomena in everyday life. Generally, the teaching and learning of mathematics aim to improve reasoning and cultivate the mind, that will provide students with systematic ways of approaching a variety of problems and as tools for analyzing and modeling situations and events in the physical, biological and social sciences [1].

However, it is not easy to understand mathematics. Learning mathematics is learning a new language. For mathematics is unique with its combination of words and symbols and compact style [2]. Non-readers, slow-readers or students with frustrating level in reading, or whose primary language is not English, are often at a disadvantage. Obviously the low performing students made a higher number of comprehension and transformation errors than high performing students [3].

This is manifested in the latest Program for International Student Assessment (PISA) results where Filipino students average score in mathematics, science and reading rank 76th out of 77 participating countries, particularly 76th in mathematics, 77th in both science and reading [4]. PISA [5] assessment framework are specifically designed to measure the 7 fundamental mathematical capabilities namely the communication, mathematizing, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal and technical language and operations, and using mathematical tools, which all require mathematics comprehension. Particularly, PISA stages of mathematization, including (1) comprehending a task, (2) transforming the task into a mathematical problem, (3) processing mathematical procedures, and (4) interpreting or encoding the solution in terms of the real situation [6] .Hence, these results exhibited that Filipino students are poor in these mathematical capabilities.

The same observations were also found by Wijaya et al., [3] when they study Indonesian students, their data analysis revealed that most of students' errors were related to the understanding of meanings of the context-based tasks and comprehension errors particularly, the selection of relevant information. Further, researchers suggested that many unsuccessful problem solvers often rely on the direct translation strategy (like looking for numbers and keywords) and fail to provide correct answers when problems include important implicit information [7,8].

To comprehend mathematics, every word and abstract symbol must be read (or written) and understood with precision such as solving word problems (WPs). It requires numerical processing and comprehension, thus, one has to know the meaning of individual words and also possess the skills to integrate the meanings of these words into semantically more complex meanings [9,10]. WPs presented in written form place significant demands on reading comprehension and other literacy skills, such as vocabulary, at the same time, it is essential to identify the problem type in order to activate the existing mathematical knowledge structures [10,11]. Hence, one has to have both linguistic and mathematical knowledge, and be able to flexibly operate between these different knowledge types to be able to solve mathematical word problems [10]. Non-routine WPs tasks require high levels of text comprehension skills [8]. It was also emphasized by Fuchs, Fuchs, Seethaler, & Craddock [12] that embedding language comprehension within schema-based word problem intervention provides students with an additional boost in word problem performance. Thus, practicing with more demanding WPs is not only beneficial for mathematics learning but can also be an effective way to improve advanced mathematics comprehension skills [8].

It is essential then to focus on building students' mathematics comprehension rather than merely developing superficial understanding through procedural learning [13]. Nagy stressed that all too often mathematics teaching approaches set more emphasis on the importance of *'How?'* and supersedes that of *'Why?', hence,* teachers need to be encouraged to present mathematics in a variety of ways which enhance the systemic understanding of concepts and the development of a systematic methodology.

In designing mathematical tasks, a teacher should assure that it aims to improve students' mathematical comprehension by giving students opportunities for *making sense* and process its own comprehension through *showing representations* of the tasks at hand. For according to Fuentes [2] reading mathematics equations has a unique directionality, quite different from ordinary language patterns and frustrating for a newcomer to mathematics because mathematics has unique vocabulary, for some words are special to mathematics, some are borrowed from ordinary usage, and some are familiar words with new and different meanings. Moreover, giving time for students to formulate their *solution and explain* how they arrive in their answer will also enhance students mathematics understanding [14] and *summarizing* one's process may also promote comprehension [15]. Hence, this study aimed to explore the application of the 4S (*Sense Making, Showing Representations, Solution and Explanation, and Summarization*) Learning Cycle Model in mathematics to enhance students' mathematics comprehension. 4S Learning Cycle Model may change the paradigm of learning, from the old paradigm where teacher as center of learning into a new paradigm in which students become the center of learning, and teacher as a motivator and facilitator.

2. Theoretical Framework

Comprehension is the retrieval and integration of information about something of which one is aware and occurs in concrete and abstract contexts. The richness and complexity of contexts that can be comprehended is one measure of intelligence [16]. Comprehending a given problem tasks requires essential other skills other than simple reading of the text. Kyttälä & Björn [10] suggested that the reading comprehension process involves the construction of a mental representation based on the text. Thus, s*howing representations* as one of the component of *4S Learning Cycle Model* through illustrating models will help students to understand the word problems. The concept of representations can be credited back to the constructivist concepts of intellectual development theory [17] which was outline from Piaget's [18] propositions. Bruner enumerated three modes of representations namely the *concrete stage* which involves a tangible hands on method of learning. In mathematics education, manipulative are the concrete objects with which the actions are performed. Second, the *pictorial stage* which involves images or visuals to represent the concrete situation enacted in the first stage. One way of doing this is to draw images of the objects on paper or to picture them in one's head. Other ways could be through the use of shapes, diagrams and graphs. Third, is the symbolic (language-based) or the *abstract stage* which takes the images from the second stage and represents them using words and symbols. The use of words and symbols allows student to organize information in the mind by relating concepts together. The words and symbols are abstractions. Language and words are ways to abstractly represent the idea.

This study was also founded on Russell [19] sense making model which theorized that sense making is the process of searching for a representation and encoding data in that representation to answer task-specific questions. According to their theory, making sense of a body of data is a common activity in any kind of analysis that requires different operations both cognitive and external resources. They argued that when a person was confronted with problems that have large amounts of information, he or she has an array of resources that can be used -- both internal cognitive resources and external resources for information storage and computation. The methods for carrying out this task can be described in terms of operations, such as representations through finding data, encoding and using the encoded representations. So when students were given problem tasks, which can be considered as information-rich data, they will undergo a process of operation such as retrieving cognitive resources like recalling previous related concepts learned and making connections, and if they are in groups, an opportunity to interact and discourse among peers could occur, hence helping them to comprehend the problem at hand.

The third component of 4S Learning Cycle Model is *solutions and explanation*. The theory of conceptual fields [20] hypothesized that, to establish better connections between the operational form of knowledge, which consists in action in the physical and social world, and the predicative form of knowledge, which consists in the linguistic and symbolic expressions of this knowledge. Vergnaud [20] further stressed that without words and symbols, representation and experience cannot be communicated; on top of that, thinking is often accompanied, or even driven, by linguistic and symbolic processes. As observed when students are asked to write or pose their work on the board and explain it to the class, what they do most of the time is to read what they have written. They do not really explain the thinking that they used which enabled them to develop a solution or obtain the required answer. To enhance mathematics comprehension and thinking, 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.

Finally, *summarization* can be used successfully in many ways in the mathematics classroom. It can increase mathematics comprehension through giving them opportunities to see and think about the material on different context and discuss them with their peers. If students are struggling with a concept, their peers' explanations may be what they need to help them understand it and those explanations can come through summarizing. Synthesizing also makes understanding visible to teachers [15].

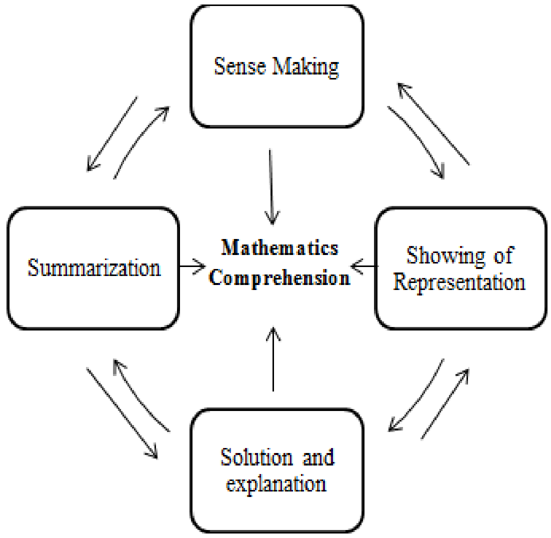

Figure 1. 4S Learning Cycle Model

Grounded on the preceding theories, this study adopted the model in Figure 1 above, the 4S Learning Cycle Model with the following components: sense making, showing representations, solution and explanation, and summarization aimed to promote students' mathematics comprehension. This study mainly investigated the effect of 4S Learning Cycle Model to students' mathematics comprehension

3. Objectives of the Study

Current researches in mathematics comprehension so far explored on the relation of reading comprehension and its implication to problem solving skills and conducted mostly among elementary or secondary students. However, seldom explored this variable among the tertiary students preparing to be mathematics teachers. Building strong foundation on concepts in mathematics and problem solving for future mathematics teachers is essential for the effectivity and efficiency of teachers depend greatly on its capability and quality [21]. Henceforth, this study aimed to determine whether the 4S Learning Cycle Model had influenced the students' mathematics comprehension.

4. Methodology

The study used the pretest - posttest quasi-experimental design to determine the effects of 4S Learning Cycle Model to students' mathematics comprehension. The experimental group was exposed to treatment which utilized the 4S Learning Cycle Model while the control group was exposed to Polya Method of Problem Solving. The performances of the students were measured using their test scores. The study utilized the validated 24-item multiple choice teacher-made test. The study was conducted for a semester.

The participants of the study were the two intact classes of freshmen education students in College and Advanced Algebra at the University of Science and Technology of Southern Philippines. One section was randomly assigned as the experimental group and the other as the control group.

At the start of the study, pretest was given to both control and experimental groups. Teacher-researcher was the one facilitating learning. The classroom environment was created which facilitated an active, responsible and engaged community of learners. The students were divided into small groups and each student was given an activity sheet. The activity began by giving an open-ended, engaging, and challenging task that the students had the ability to solve.

In the experimental group, the 4S Learning Cycle was employed to solve the problem. Students started the activity through *making sense* of the problem by discussing among peers in the group, using their prior knowledge and experiences. During the discussion, students' draw *representations* to visualize their understanding of the problem which help strengthen their comprehension of the tasks at hand. These led them to translate the given conditions in the problem to an expression or equation to arrive at the correct *solution*. After having the solution of the problem, students were encouraged to communicate their understanding of the task through explaining their solution to their group-mates. Each group was asked to present their solutions and summarized the concepts they learned. Here, students were given the chance to discuss the intended mathematical ideas developed with the teacher's guidance to avoid misconceptions (if there is).

On the other hand, the control group was taught using the Polya's method of problem solving. The first step was understanding the problem. In order to show an understanding of the problem, students need to read the problem carefully. Once the problem was read, students listed in the space provided all the components and data that were involved. This was where they assigned variables. The second step was devise a plan. Students translated the conditions in the problem into an equation, drawn the diagram or illustrate if needed. They devised a plan in order to solve the problem. The next step which is step 3 was carrying out the plan or this means solving the problem. The students solved the problem. They discussed with their group mates how to solve the problem and they wrote on their activity sheet their solutions. The last step for Polya's problem solving method was looking back. The students checked their solution and tried to see if they used all the information and if their answer made sense.

To describe the mathematics comprehension level, mean and standard deviation of the pretests and posttests were computed. To determine the influence of the two methods of teaching on students' mathematics comprehension, 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 mathematics comprehension level as shown in the rating scale below:

Table 1. Mathematics Comprehension Rating Scale

Mean Score Range	Description/Interpretation
18.00-24.00	Mastery
12.00-17.99	Near Mastery
0.00-11.99	Low Mastery

5. Results and Discussion

Table 2 shows the pretest and posttest mean scores and standard deviation and descriptive level of students' mathematics comprehension on Linear Equations, Quadratic Equations, Systems of Linear Equations and Linear Inequality.

Table 2. Summary of the mean and standard deviation

Time of Appraisal	Method of Teaching	n	Mean	SD	Level
Pretest	4S	38	10.868	3.112	Low Mastery
	Polya	38	11.921	3.044	Low Mastery
Posttest	4S	38	16.158	3.140	Near Mastery
	Polya	38	15.131	3.256	Near Mastery

The results indicate that the students' mean scores from both groups were in the low mastery level in the pretest, an indication that they have little background in the subject. It can be observed also that the pretest mean scores have a difference of 1.052 only where the control group is slightly higher than the experimental group. This means that the two groups of students had comparable mathematics comprehension before the treatment was administered.

In the posttest, the students taught with 4S Learning Cycle Model shows a mean score higher than the group exposed to Polya Method of Problem Solving. The results revealed that both groups have increased their posttest mean scores indicating that both groups have manifested improvement from low level before the treatment was administered to near mastery after the treatment was administered. However, it is noticeable that the experimental group has improved more in mathematics comprehension compared to the control group. The posttest mean score of students taught with 4S learning cycle is 1.027 higher and nearer to mastery level.

The standard deviation of the pretest scores of those taught with 4S Learning Cycle Model is higher compared to those students taught with Polya Problem Solving Method. This means that before the treatment, the scores of the students in the experimental group have a wider spread compared to the scores of the students in the control group. However, in the postest, the group exposed to 4S Learning Cycle Model has a lower standard deviation than the control group who were taught with Polya Problem Solving Method. This result revealed that the students in the experimental group have more improved mathematics comprehension after the treatment was administered. The students' scores in the experimental group are more closely located about the mean of 16.158 indicating a more consistent or homogeneous set of students in terms of performance in the mathematics comprehension test. To verify whether the difference was significant, ANCOVA was further used.

Table 3. One - way ANCOVA Summary for Students' Mathematics Comprehension

Source	SS	df	MS	F	P
Adjusted Means	49.02	1	49.02	6.79	0.011104
Adjusted Error	526.68	73	7.21		
Adjusted Total	575.7	74			

Table 3 presents the summary of the analysis of covariance of pretest and posttest scores for students' mathematics comprehension of the experimental and control groups. The analysis yielded a computed probability value 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 mathematics comprehension of the students exposed to 4S Learning Cycle Model is significantly higher than those exposed to Polya Method of Problem Solving. This happened because when the students were exposed to 4S Learning Cycle Model, they were provided the opportunity to comprehend the given tasks through an active process following the four components-cycle. Communicating how one makes sense of the task and showing representations by undergoing a process of operation such as retrieving cognitive resources like recalling previous related concepts learned and making connections and breaking information-rich data into smaller chunks of information [19,22] helped students understand the problem. Explaining the solutions, and summarizing concepts learned from the activity, allowed students to interact and discourse among peers. This also facilitates the struggling students' understanding and comprehension of the problem at hand [15].

6. Conclusion and Recommendation

Based on the findings of the study, 4S Learning Cycle Model positively influenced the students' mathematics comprehension. On this basis, the teachers may adapt this teaching strategy to improve the mathematics comprehension skills of their students. The mathematics teachers may be given training on how to apply this strategy in their mathematics class. School principal and supervisors may support the implementation of 4S Learning Cycle Model in mathematics classroom to enhance the mathematics comprehension skills of the students. Similar studies maybe conducted in a wider scope using different population in different learning institution to promote the generalization of the results.

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