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STUDENTS' LEVEL OF PROCEDURAL FLUENCY AND DIFFICULTIES IN COLLEGE ALGEBRA: A FLEXIBLE LEARNING SET-UP

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Abstract
Various changes and advances have taken place in the ways of teaching and learning. With the encountered global pandemic crisis, flexible learning has been practiced particularly in state universities and colleges. This study sought to determine the level of procedural fluency in College Algebra as well as the difficulties and interventions applied by tertiary students of Cotabato State University (CSU) in the flexible learning set-up. The period covered by the study was during the first semester of the school year 2021-2022. The respondents were a sample of 30 first-year mathematics major students of CSU. It used mixed methods; the quantitative approach was utilized to know the students' knowledge of procedures in solving mathematical problems while the qualitative approach was utilized to explore the difficulties of the students in learning mathematics as well as the coping strategies that can serve as basis for mathematics intervention program. The findings revealed that most of the respondents have a low level of procedural fluency in College Algebra, particularly emerging in the understanding the problem, devising a strategy, and solving steps while inept in the problem-solving checking process. On the part of new normal learning, difficulties were experienced such as poor knowledge of the prerequisite skills and unstable internet connection. As part of their interventions, facing the encountered problems, practicing repeatedly, and watching online video tutorials were applied. Based on the findings of the study, it is concluded that the first-year students have low level of procedural fluency in College Algebra problem-solving particularly in the Polya's principles of understanding the problem, devising a plan, carrying out the plan, and checking the answer. Because of the learning challenges encountered by the students, it is recommended to develop step-by-step video tutorials that can address their problem-solving difficulties and supplement their learning in the flexible mode of delivery.

Keywords: *Polya's Principles, Procedural Fluency, Learning Difficulties, Interventions, Mixed Methods*

INTRODUCTION

Various changes and advances have taken place in the ways of teaching and learning. With the encountered global pandemic crisis, flexible learning has been practiced particularly in state universities and colleges. CHED Memorandum Order No. 04, series of 2020 states the guidelines on the implementation of flexible learning where it is emphasized that flexible learning as a mode of delivery shall be adopted beginning academic year 20202021. As the new mode of learning has been implemented, students are given freedom in how, what, when and where they learn. However, learning something new becomes harder, especially at the beginning when students are likely to struggle and make mistakes.

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As cited in the study conducted by Lin et al. (2016), students face problems that are difficult to solve in a face-to-face teaching framework for the beginners, particularly in mathematics-related subjects. These problems are usually associated with various internal and external factors. Students may lack the interest, motivation, and positive attitude, and when it comes to content, they pay little or no attention to understanding basic mathematics concepts (Abramovitz et al., 2012).

Among the different subjects or courses to be taken and mastered by the students in the different levels, mathematics is undeniably one of the most challenging subjects, especially in the new normal setting. For tertiary students, they are expected to be equipped with essential knowledge and skills, particularly in Algebra before proceeding to the next year level. That is why the researcher seeks to determine the students' level of procedural fluency in College Algebra problem-solving, particularly in the levels of understanding the problem, devising a plan, carrying out the plan and checking the answer, exploring their learning difficulties and interventions applied in the new normal, and designing an intervention program that will help students improve their problem-solving skills in College Algebra. The results of the study can provide awareness for the level of mathematical problem-solving of the students in the implemented mode of delivery. Also, it can serve as a basis for the conduct of mathematics intervention program in Cotabato State University.

METHODS

Research Design

Mixed methods design particularly explanatory sequential was utilized in the study. For the quantitative phase, weighted mean was utilized using Jeffreys's Amazing Statistics Program (JASP) to describe the respondents' level of procedural fluency based on the four principles in problem-solving developed by Polya (1973) and his provided rubric and on the content of mathematical problems under College Algebra. For the qualitative phase, themes and thematic statements were used to explore the learning difficulties and interventions applied by the students in College Algebra. As for the process of gathering the data, the researcher asked permission from Cotabato State University (CSU) administration, particularly the dean of the College of Teacher Education (CTEd) to allow the conduct of the study. After this, a College Algebra problem-solving test which covers mathematical problem topics on the basics of sets, special products, factoring methods, rational exponents, rational expressions, rationalization of radicals, equations and inequalities, real and imaginary numbers, word problems involving simple equations and fractions were given to a sample of 30 CTEd first-year students of CSU and was followed by the conduct of a one-onone interview for validation of the quantitative results.

RESULTS and DISCUSSION

Table 1

Level of Procedural Fluency of Students in College Algebra in Relation to the Four Problem-Solving Principles (n = 30)

Mathematical Problem Topics	Weighted Mean ($\bar{x}$) Understand a Plan	Devise the Plan	Carry Out the Problem	Reflect on the Problem
Basics of Sets	1.90	1.83	1.63	0.77
Special Products	1.50	1.50	1.00	0.77
Factoring Methods	1.43	1.43	1.40	0.77
Rational Exponents	1.37	1.37	1.33	0.70
Rational Expressions	1.47	1.47	0.77	0.77
Rationalization of Radicals	1.37	1.37	1.33	0.70
Equations / Inequalities	0.70	0.70	0.00	0.00
Real / Imaginary Numbers	0.63	0.63	0.00	0.00
Word Problems Involving Simple Equations	1.23	1.23	1.20	0.67
Word Problems Involving Fractions	0.60	0.60	0.57	0.57
Overall	**1.22**	**1.21**	**0.92**	**0.57**

Note:

Range of Weighted Means	Description
2.25 - 3.00	*Proficient (P)*
1.50 - 2.24	*Developing (D)*
0.75 - 1.49	*Emerging (E)*
0.00 - 0.74	*Inept (I)*

As reflected in Table 1, it was revealed that most of the respondents were emerging on the levels of understanding the problem (= 1.22), devising a plan (= 1.21), and carrying out the plan (= 0.92), while most of them were inept on the level of reflecting on the problem (= 0.57). The result implies that most of them showed a partially developed understanding of the given mathematical problems and identified a few specific factors that influence the approach to a problem before solving it. On the level of devising a plan to solve the problem, most of them can identify a viable strategy especially when keywords are provided and plan is straightforward. Also, most of them were not able to demonstrate well-developed thought or reasoning in carrying out the plan. Sometimes, they recognized the need for multiple paths to carry out the plan especially if the first attempt failed, but they did so with limited proficiency. On the level of reflecting on the problem, most of them failed to analyze or synthesize results and rarely check their

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solution. Overall, the result suggests that majority of the respondents have low level of procedural fluency in College Algebra particularly on the four principles or steps in problem-solving.

In line with this, it was revealed in the study conducted by Thiangthung (2016), more than 93 percent of students used Polya's steps 1, 2 and 3 in solving word problems, but only 42.80 percent used step 4. In the international level, the low problem-solving process skills of students were also evident. As cited by Simamora, et al. (2019), Indonesian students' capacity to solve mathematical problems is still lacking (Jerizon et al., 2018; Nidya et al., 2015). According to Simamora et al. (2017), the results of interviews from teachers revealed that word problems in mathematics were very difficult for students. It was also found that many students disliked mathematics because it was too tough for them to understand. The same matter, the low mathematical problem-solving ability of students, also reported when making observations in the level of junior and senior high schools.

Table 2

Level of Procedural Fluency of Students in College Algebra in Relation to the Mathematical Problem Topics (n = 30)

Mathematical Problem Topics	Weighted Mean ($\bar{x}$)	Description
Basics of Sets	1.53	Developing
Special Products	1.19	Emerging
Factoring Methods	1.26	Emerging
Rational Exponents	1.19	Emerging
Rational Expressions	1.12	Emerging
Rationalization of Radicals	1.19	Emerging
Equations / Inequalities	0.35	Inept
Real / Imaginary Numbers	0.32	Inept
Word Problems Involving Simple Equations	1.08	Emerging
Word Problems Involving Fractions	0.58	Inept

Note:

Range of Weighted Means	Description
2.25 - 3.00	*Proficient (P)*
1.50 - 2.24	*Developing (D)*
0.75 - 1.49	*Emerging (E)*
0.00 - 0.74	*Inept (I)*

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As shown in Table 2, it was revealed that the majority of the respondents were emerging in solving mathematical problems concerning the factoring methods (= 1.26), rational exponents (= 1.19), rationalization of radicals (= 1.19), special products (= 1.19), rational expressions (= 1.12) and word problems involving simple equations (= 1.08), while most of them were inept in solving mathematical problems concerning real and imaginary numbers (= 0.32), equations and inequalities (= 0.35) and word problems involving fractions (= 0.58). However, most of them were developing only in solving mathematical problem concerning the basics of sets (= 1.53). Still, the overall result suggests that most of the students have low level of procedural fluency in College Algebra particularly in solving the identified mathematical problem topics. A cited in the study conducted by Gray (2018), "Putting problem-solving in a hierarchy of skills to be acquired by students leads to certain consequences for the role of problem-solving in the curriculum" (Stanic & Kilpatrick, 1989, p. 43). Because of the difference in hierarchy between solving routine and non-routine problems, only a few advanced students are ever exposed to non-routine problems; hence, many are never exposed to this kind of problems.

Learning Difficulties of Students in College Algebra under the New Normal

The perception of the students on the difficulties encountered in the new normal learning of College Algebra was presented in textual or descriptive form. It included the themes and thematic statements.

Difficulty in solving word problems especially involving fractions

Learner 1: *Difficult because it's fraction.*
Learner 3: *It is difficult since fractions are involved, and it's my weakness in math.*
Learner 6: *I'm also confused about how to solve fraction.*

This theme reveals from the perspective of the students that dealing expressions, equations and inequalities that involve fractions is truly challenging. Negative notion is associated with the inclusion of fractions in mathematical problems. Solving that includes rational numbers turns out to be difficult from students' point of view and because of this, the concept becomes part of their weaknesses in dealing with mathematics. As cited in the study conducted by Namkung & Fuchs (2019), it was underlined that many students find learning fractions difficult, and the challenges connected with learning fractions have been widely documented (e.g., NMAP, 2008; Nunes & Bryant, 2008; Stafylidou & Vosniadou, 2004). For example, fractions were rated as the second most important weakness area explaining students' difficulty understanding algebra in a national survey of algebra teachers (Hoffer et al., 2007).

Difficulty in problem-solving due to undeveloped prerequisite skills

Learner 3: *But it depends on your background and how strong your math skills are before you start learning algebra and how to solve problems with ease.*
Learner 4: *The reasons of having difficulties are comprehension, translation and solving process skills.*
Learner 5: *I think sir I am confused in the formulas to be used.*

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This theme points out the importance of background in problem-solving. The basic requirement needed to effectively solve word problems in College Algebra is the mastery of the fundamentals of mathematics. Concepts like the use of formulas and skills in comprehensions such as translating the verbal phrase into the mathematical phrase or vice versa are prerequisite skills in solving mathematical problems. Bahar and Maker (2015) as cited by Simamora et al. (2019) stated that the concept of problem-solving is referred to by scientists as a high-level thinking process consisting of intellectual ability and major cognitive processes. A problem-solver can apply Polya's (1973) approach or steps to solve a word problem, which states that one must first comprehend the situation and perceive clearly what is requested. Second, one needs to see how things are linked, how the unknown is linked to the given facts, in order to generate ideas for plan solutions. Third, one should put the strategy into action. Fourth, the problem-solver must revisit the solutions that have been found, review them again and discuss them.

Difficulty in learning because of unstable internet connection

Learner 2: *I struggled because of poor internet connection*
Learner 5: *Because of the connection my understanding of the lessons was affected.*
Learner 6: *It is because of poor connection that's why College Algebra becomes difficult to learn.*

This theme highlights internet connectivity as a factor that affects students' learning of College Algebra. Poor internet connection serves as a challenge for the students to effectively learn the subject. In particular, understanding of the lessons is harder if the connection is unstable. A stable internet connection was one of the challenges that students encountered in online learning according to Fabito et al. (2021). Casillano (2019) mentioned in his study that only a small percentage of students have internet access, making it difficult for them to actively engage in the elearning platform.

Interventions Applied by the Students in the Encountered Learning Difficulties

The intervention applied by the students in the learning difficulties experienced in the new normal learning of College Algebra was presented in textual or descriptive form. It included the themes and thematic statements.

Facing the problem and practice repeatedly

Learner 1: *I handle it through practice that's why I am always practicing.*
Learner 4: *I really have to study it because I believed that everything can be learned if given a full attention.*
Learner 5: *I face the challenge in problem-solving because I want to increase my knowledge and skill in College Algebra.*

This theme points out one intervention applied by the respondents in their encountered learning difficulties. Facing the problem enables them to find immediate ways to cope up with their problems and eventually resolve them with the help of internal and external support. Practicing solved problems repeatedly and being patient help them address their learning gaps. Polya (1973) stated that students need intellectual courage, intellectual honesty, and wise restraint

when they solve problems. Students can acquire these characteristics by participating in problem-solving activities in class that help them get a better understanding of mathematics and become better problem-solvers.

Watching YouTube step-by-step tutorial in mathematics is of great help

Learner 2: *I am watching videos on YouTube especially in the problem-solving process.*
Learner 3: *Teachers must be able to explain step-by-step on how to solve a problem even in the new normal setting.*
Learner 6: *Use visuals and images in presenting and explaining lessons.*

This theme emphasizes the use of YouTube as a learning resource or instrument in understanding the concepts in College Algebra. Students prefer the systematic way of teaching problem-solving so that learning would be easier. Watching YouTube becomes an alternative way of students in mathematics learning and coping in the new normal. YouTube is one of the most popular online databases for accessing video tutorials created by and for people on a variety of topics. Many foreign colleges use YouTube videos in their classrooms. "YouTube is the most viewed website with more than 1.7 billion projected monthly views from organic search," says Joshua Hardwick (Iftikhar et al., 2019).

Table 3

Action Plan Based on the Encountered Learning Difficulties and Suggested Intervention by the Respondents

Objectives	*Strategies*	*Activities*	*Persons Involved*	*Time*	*Expected Output*
To make video tutorials in College Algebra particularly on the topic about solving mathematical problems that involves equations, inequalities, complex numbers, and fractions.	Integrate the video tutorials in the college and advanced class period.	Upload the videos in the researcher's YouTube channel and make these available both online and offline	First year students of Cotabato State University	S.Y. 2022-2023	Improved level of procedural fluency in college Algebra

CONCLUSIONS

Based on the findings of the study, it is concluded that the first-year students have low level of procedural fluency in College Algebra problem-solving particularly in the principles of understanding the problem, devising a plan, carrying out the plan, and checking the answer. As part of the new normal learning, the students encountered challenges such as difficulty in solving word problems due to poor knowledge on the prerequisite skills and unstable internet connection.

On the other hand, facing the problems, practicing repeatedly, and watching online mathematics tutorials were applied to cope with the challenges and supplement their learning in the flexible mode of delivery.

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