

THE PERCEPTION OF LOW-ACHIEVING DIPLOMA STUDENTS TOWARDS JIGSAW COOPERATIVE LEARNING METHOD AND POLYA'S PROBLEM SOLVING MODEL IN LEARNING INTRODUCTION TO QUANTITATIVE TECHNIQUES

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Abstract – This qualitative study was carried out to explore the challenges faced by low-achieving diploma students in the subject of Introduction to Quantitative Techniques. In addition, this study explored how the Jigsaw cooperative learning method and the Polya Problem Solving Model can help low-achieving students and their perception of this alternative method of learning. This study was conducted at a private college in Sabah, Malaysia involving five low-achieving second-semester Management Diploma students. Data was collected through interviews, field notes, and document analysis. The study's findings show that low-achieving students needed help understanding the question's requirements and could not identify the correct formula in the solution. Polya's Problem Solving Model helped students better understand the questions' requirements and solve step by step long-sentence problems. Help from classmates who act as facilitators improved the skills of low-achieving students in understanding concepts and formulas and solving long-sentence problems while obtaining better grades. The results of the study provide positive implications for low-achieving Management Diploma students to improve their problem-solving skills in the subject of Introduction to Quantitative Techniques.

Keywords – Introduction to Quantitative Techniques, Jigsaw Cooperative Method, Low-Achieving, Polya Problem Solving Model

I. INTRODUCTION

Appropriate teaching and learning methods are important to ensure an effective teaching and learning process, especially to deal with the problems of low-performing students in the subject of Mathematics. According to Md Sah (2012), students should be given the opportunity to hone their skills in researching, solving problems and communicating or interacting while solving Mathematical problems. The planned activities should allow students to see the continuity between the Mathematical concepts and make connections about what they learn in real life. The opportunity to relate knowledge and skills to a wider context will encourage them to learn and become lifelong learners.

One of the learning methods that is proven to be effective in improving the academic achievement of students of all ages is the cooperative learning method

(Hornby, 2009; Azmin, 2016). Cooperative learning methods are situations where learning occurs when two or more students work together to complete a task (Siegel, 2005).

Although cooperative learning provides different options to educators with a teacher-centred approach, there is still a problem for teachers to choose cooperative learning techniques that are more appropriate and effective compared to other techniques. A further problem exists regarding the level of competence of teachers to implement different cooperative learning techniques. Planning to choose the appropriate method in teaching Mathematics needs to take into account the ever-changing world situation. This is because learning Mathematics today needs to prepare students to play their role in the future society. In today's globalized world, a person who is competent in Mathematics can further increase opportunities and choices to determine their future (National Council of Teachers of Mathematics, 2000). This is important to equip students with knowledge and skills in the field of Mathematics, such as reasoning skills, problem-solving, communication and the ability and initiative to learn independently.

Jigsaw is one of the methods used in the implementation of cooperative learning, making cooperation a priority by providing support for students to cooperate and eliminating competition in the class, and this Jigsaw method is seen as an alternative to traditional teaching methods (Tran & Lewis, 2012). In this study, the Jigsaw learning method is expected to help overcome the problems that exist in learning the subject of Introduction to Quantitative Techniques as well as the characteristics of interaction that need to be practised as an effective teaching and learning method. For this reason, this study was conducted to explore if the use of the Jigsaw cooperative learning method can improve the achievement of low-achieving students in the subject of Introduction to Quantitative Techniques.

Apart from the Jigsaw method, the Polya Problem Solving Model is also used to overcome students' problems in problem-solving questions in the subject of Introduction to Quantitative Techniques. The Polya Problem Solving Model is a model that is often used by educators and researchers to solve Mathematics problems among students (Yuan, 2013; In'Am, 2014; Lasak, 2017). Previous studies have shown that the use of the Polya Problem Solving Model has been proven to improve student performance in various subjects (Eksi, 2005; Perveen, 2010; Ali et al., 2010). In a study carried out by

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Bowman (2010), in particular, the Polya Problem Solving Model proved to be effective in improving mathematical thinking through oral and written communication when solving word problems.

II. PROBLEM STATEMENT

Mathematics is a compulsory subject that must be taken by Diploma of Management (DPG) students as the course requires students to be proficient in calculations before taking other subjects such as Economics and Finance subjects. A foundation in the calculation subject is very important for students before taking on more difficult subjects in the following semester. DPG is a course aimed at business and management, where students need to be strengthened with creative and critical thinking skills. As such, students are required to either obtain credit in the mathematics subject during SPM or take an additional subject which is Reinforcement Mathematics, during the first semester. In the second semester, DPG students are required to take another Mathematics subject which is Introduction to Quantitative Techniques (IQT). IQT is a subject about Mathematics application in real-world life.

However, most of the students who take IQT find it difficult to describe the real situation in each question. This subject is also a prerequisite to another core subject, Research Approach. The topics taught in this subject include the basics of statistics, mathematics and their applications in a business environment. There are eight chapters, namely data collection, data presentation, the measure of central tendency, the measure of dispersion, index numbers, the use of graphs in economics, linear programming, and financial mathematics. Almost eighty per cent of the topics taught in this subject are topics that have been studied at the secondary school level. However, there are still many students who show poor performance in this subject. This can be seen based on the performance analysis of the final semester exam in February 2020 in the IQT subject (Table 1), where 70% of the students got low grades (C+ to F). Therefore, there is a need to study what challenges students face in learning this subject and also explore whether the Jigsaw cooperative learning method and the Polya Problem Solving Model can improve the performance of low-achieving students in the IQT subject. The results of this study are expected to help Diploma in Management (DPG) students in the future, as well as help other instructors and researchers to understand the perception of students in using appropriate alternative methods to improve their performance.

TABLE 1: ANALYSIS OF STUDENT PERFORMANCE IN THE FEBRUARY 2020 FINAL SEMESTER EXAM ON THE SUBJECT OF INTRODUCTION TO QUANTITATIVE TECHNIQUES

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	F	Total
No.	5	2	3	5	3	7	14	3	3	5	10	60
%	8.33	3.33	5.00	8.33	5.00	11.67	23.33	5.00	5.00	8.33	16.67	100

III. LITERATURE REVIEW

Cooperative Learning

Cooperative learning is a group concept and technique to help maximize the benefits of collaboration among students (Jacobs et al., 2008). Johnson and Johnson (1999) stated that cooperative learning involves cooperation between students to achieve a common goal, discuss the material with each other, help each other understand it, and encourage each other to work hard. Cooperative learning is widely recognized as a pedagogical practice that promotes socializing and learning among students from preschool to higher education, and it crosses subjects of different domains (Gillies, 2016). Various theoretical perspectives on learning, including behaviourism theory, sociocultural theory, human psychology, cognitive psychology, social psychology, and Piaget's developmental psychology, have been used to develop and justify different approaches to cooperative learning (Jacobs et al., 2008).

Jigsaw Cooperative Learning Method

The Jigsaw cooperative learning method is one of the methods of cooperative learning. It was introduced by Aronson and Patnoe (1997), and there are many researchers who have adapted and used a revised version of the Jigsaw method in classes of different levels and different subjects (Hedeen, 2003; Sahin, 2010). In this Jigsaw cooperative learning method, each group will send members to form an expert group, and then the members in the expert group will return to their original group to share their knowledge with their group mates. The main motive in the Jigsaw method is that each student in a group will be an expert in a certain topic and be responsible for teaching the group mates about what they have learned. According to Karacop (2017), the Jigsaw method encourages student participation in the classroom, where students have an important role in achieving success, and this success depends on the cooperation and active participation of the students involved. This Jigsaw method is seen to increase the diversity of learning experiences and cooperative social skills (Perkins & Tagle, 2011). In an experimental study carried out by Yemi et al. (2018) on 80 high school students, the results show that teaching Mathematics through the Jigsaw method is more effective than teaching traditional methods in improving academic achievement. In addition, the Jigsaw method is also seen to increase students' positive attitude towards learning Mathematics.

Polya Problem Solving Model

In general, problem-solving can help a person to adapt to unexpected changes and problems in their career and other aspects of their lives. In Mathematics Education, in particular, problem-solving is seen as one of the important elements because problem-solving in Mathematics helps students develop various complex mathematical structures and acquire the ability to solve various real-life problems (Tarmizi & Bayat, 2012). Regarding the skills and approaches needed to solve these problems, Polya (1945) formulated a four-step approach to solving problems that starts with understanding the

problem, planning a strategy, implementing the strategy, and revising. Understanding the problem is the first step to knowing the problem at hand by asking questions such as 'Do you understand all the words used in stating the problem' and 'Can you restate the problem in your own words?'. Although such things are often considered meaningless and ignored by students, however, students are often hindered in their efforts to solve problems simply because they do not fully understand the problem (Polya, 1945).

The next step is to plan a strategy that refers to how to solve the problem. Strategies that can be used include making lists, using formulas, guessing and checking, and solving simpler and related problems. Implementing the strategy is a step that will be implemented after planning the strategy. If the chosen strategy is not effective, then one can refer to other sources, such as textbooks. If the strategy itself still doesn't work, then the learner needs to go back to step 2 and choose another strategy. The last step is to review, where this step requires a person to evaluate the strategy used to solve the problem and whether it is effective and can really solve the problem. The Polya Problem Solving Model is often used in Mathematics subjects because of its effectiveness in improving student performance in this subject (Hadi, 2014). As in a study carried out by Lasak (2017) on 30 prospective student teachers in Mathematics, the use of the Polya Problem Solving Model proved to be effective in improving students' skills and achievement in solving Mathematics problems.

IV. PURPOSE AND RESEARCH QUESTIONS

This study was conducted to explore the challenges faced by low-achieving students in the subject of Introduction to Quantitative Techniques, explore how the Jigsaw cooperative learning method and the Polya Problem Solving Model could help low-achieving students in learning the subject of Introduction to Quantitative Techniques and explore the perceptions of high-achieving students low on Jigsaw's cooperative learning method and Polya's Problem Solving Model in learning the subject of Introduction to Quantitative Techniques. Accordingly, this study attempted to answer the following research questions:

1. What are the challenges faced by low-achieving students in the subject of Introduction to Quantitative Techniques?
2. How can Jigsaw's cooperative learning method and Polya's Problem Solving Model help low-achieving students in the Introduction to Quantitative Techniques course to get better grades?
3. What is the perception of low-achieving students towards the Jigsaw cooperative learning method and the Polya Problem Solving Model in learning the subject of Introduction to Quantitative Techniques?

V. METHOD

Study location

This study was carried out at a private college in Sabah. The college offers courses such as Bachelor's

Degree in International Business, Diploma in Management, Diploma in Accounting, Diploma in Medical Laboratory Technology, Diploma in Graphic Design, Diploma in Hotel Management, Diploma in Hotel Management, Certificate in Tourism Operations, Certificate in Health Sciences, Certificate in Business Management, and Certificate in Science Computer. Almost all of these courses require students to take the subject of Mathematics.

Study Sampling

This study used purposive sampling to select the informants of the study. The selection criteria were based on student performance and focus on Management Diploma students with low achievement in the subject of Introduction to Quantitative Techniques. Research informants were selected from Management Diploma students because there were many students who had low achievement in this subject. Since this course was taken by second-semester students, the selected research informants were students from the second semester. There were five research informants selected based on their performance in the final semester exam of February 2020. These informants were seen to show very poor performance and answered questions that were beyond the concept.

Data collection

This study used a qualitative method in the form of a case study. In this study, data was collected through semi-structured interviews, document analysis and field notes.

Interviews

Semi-structured interviews were used to understand the informants' perceptions of the problem-solving strategies that had been implemented in this study, namely the Jigsaw cooperative learning method and the Polya Problem Solving Model. Semi-structured interview questions were constructed to elicit informants' perspectives on ideas, opinions, and experiences regarding the problem-solving strategies used. Before the interview took place, the informants were informed about the details of the study and assured of ethical principles such as anonymity and confidentiality. The researcher also submitted a consent agreement letter to be filled out and signed by the informants. During the interview session, the researcher used a voice recorder to record the conversation. Semi-structured interview questions were distributed to the informants first, which aimed to help the informants generate ideas and give them the opportunity to reflect on the interview questions before being asked by the researcher. The interview session took two hours to complete.

Document Analysis

At the beginning of the study, the researcher analyzed the final semester exam result document of February 2020. This was done to determine which informants had difficulties in solving problems in the subject Introduction to Quantitative Techniques. In addition, analysis of the pre-and post-test papers was also

carried out to test the level of informants' skills and to explore the impact of the methods that had been introduced.

Field Notes

Field notes were recorded to report observations, make reflections or formulas and make other notes about what happened in the class (Creswell & Creswell, 2017). In this study, field notes were taken while the informant was performing Jigsaw cooperative method activities to recall concepts, principles, definitions and connections between concepts in the subject of Introduction to Quantitative Techniques. In addition, field notes were also taken during the activity using the Polya Problem Solving Model.

Data Analysis Procedures

The data obtained were analyzed using a thematic analysis approach. Thematic analysis is a method to identify, analyze, organize, explain, and report the themes found in the data set (Clarke & Braun, 2013). In this regard, the thematic analysis involved reading and authoring the transcripts, identifying themes, developing a coding scheme, and coding the data.

VI. FINDINGS

Challenges faced by low-achieving students in the subject of Introduction to Quantitative Techniques

Based on the findings of the interview, the researcher found that almost all informants faced problems solving long sentences. Among the problems faced by informants were not being able to understand the requirements of the question, being able to memorize formulas but not sure if they were appropriate to use, and using formulas incorrectly. The informant's statement can be referenced through the following interview excerpt:

"My biggest challenge when solving quantitative subjects is that it is difficult to understand the steps of the work, and I am also confused by the questions given."

"...in addition, it is quite difficult for me to ascertain whether or not the formula fits the question..." (Informant A)

"...my biggest challenge when solving problems in this subject is that I don't understand the questions given..." (Informant B)

"...my biggest challenge in completing the quantitative technique exercise is that I use the wrong formula..." (Informant C)

"...very challenging... not understanding the question..."

"...and mistakenly used a formula while solving a question..."

(Informant E)

Apart from that, the constraints of the current situation using online learning methods were also an additional challenge for informants due to poor internet access, as stated by informants A and D in the following interview excerpt:

"... I had an internet network problem, and it caused me to lose focus with the online learning session..." (Informant A)

"...my biggest challenge is that I have internet problems and when the lecturer wants to teach me, the internet is problematic, and I can't hear clearly..." (Informant D)

How Jigsaw's Cooperative Learning Method and Polya's Problem Solving Model help low-achieving students in the subject Introduction to Quantitative Techniques to get better grades

Based on the findings from the interviews, the informants stated that they had previously tried to memorize formulas consistently in practising problem-solving in order to help them answer tests or exams. However, after following the four steps in Polya's Problem Solving Model, the method they used now was more organized, and informants could better understand the questions. Polya's Problem Solving Model allowed them to understand problems, plan strategies, implement strategies, and revise. These processes helped the informant to be more thorough in solving problems that have long sentences and were able to reduce misunderstandings about the requirements of the question as well as the use of correct formulas. All of the informant's statements can be referenced through the following interview excerpts:

"...before I used the Polya solution method, I did not understand and did not know how to answer the question. After I used the Polya solution method and the steps given, I was able to solve the problem..." (Informant A)

"...The Polya method and the cooperative method make us feel easier to understand the questions compared to the previous method..." (Informant B)

"...the difference I got after the problem-solving method was introduced in class is that I can better understand what the question is asking and can solve the problem step by step..." (Informant C)

"...the difference is that I have an increase in scores after applying the Polya solution steps..." (Informant D)

"...when the Polya solution model method was introduced, it helped me to understand and read carefully the question we wanted to solve and what appropriate formula was used to answer the question. What kind of annuity formula is asking for, the present value of the annuity, the future value..." (Informant E)

The research findings from this interview method were also supported by findings from field notes and pre and post-tests. Based on the field notes, the researcher found that Informants A, B, and D were able to master the given topic after being introduced to the Jigsaw cooperative method. They were seen to be able to explain the topic well after getting the help of experts in their group. This finding was also supported by the findings from the pre and post-test conducted to evaluate the effectiveness of the Jigsaw cooperative method and the

Polya Problem Solving Model against low-achieving informants in the subject of Introduction to Quantitative Techniques. The results of pre and post-test results showed that there was an increase in the informant's achievement in the subject of Introduction to Quantitative Techniques after being exposed to the Jigsaw cooperative method and the Polya Problem Solving Model (Table 2).

TABLE 2: PRE AND POST-TEST RESULTS

Informant	Pre-test		Post-test	
	Marks (Percentage)	Grade	Marks (Percentage)	Grade
A	13 (32.5%)	F	25 (62.5%)	B-
B	15 (37.5%)	F	30 (75%)	A-
C	14 (35%)	F	20 (50%)	C
D	14.5 (36.3%)	F	25 (62.5%)	B-
E	10.5 (26.3%)	F	19.5 (48.8%)	C-

Perception of low-achieving students towards the Jigsaw Cooperative Learning Method and the Polya Problem Solving Model in learning the subject of Introduction to Quantitative Techniques

Based on the findings from the interview, Informants think that the use of the Jigsaw cooperative method can help them improve their ability to understand concepts and formulas through peer guidance. Informants said that Polya's Problem Solving Model helped them organize their work in an orderly way to answer each part of the question by visualizing, focusing, evaluating the answer and understanding the question's intent. These informants found that they were able to solve each question step by step and were able to reduce errors when answering questions, especially errors in the use of formulas. All of the informant's statements can be referenced through the following interview excerpts:

"...Polya Model is very helpful for me to solve questions by using step-by-step solutions..."

"...This method is very easy to use because the working steps are broken down so that it is easy for me to understand..." (Informant A)

"...this method really helped me answer all the questions in the subject of introduction to quantitative techniques..."

"... with this method I can easily understand all the questions in this subject with the guidance of a clever friend..." (Informant B)

"... Polya solving problem model with the cooperative method is very helpful for me to solve problems because this method teaches me to answer step by step with the guidance of a friend" (Informant C)

"... Polya problem-solving model was very helpful because it taught me to take one step at a time to answer the questions so as not to make any more mistakes..." \ (Informant D)

"...yes, because understanding the question is the first thing, polya's solution helped me a lot, he helped me a lot to understand the question and carefully understand what the question wanted and then I came up with the appropriate formula to use to answer the question..."

(Informant E)

VII. DISCUSSION

In this study, low-achieving informants face difficulties in solving long-sentence problems. Among the challenges they face is difficulty in understanding the requirements of the question and not being able to identify the correct formula in the solution. In addition, the weak internet network is also seen as a challenge faced by the informants in learning the subject. Problems with long sentences make informants confused with the concepts and formulas that need to be used. Garderen (2006) states that deficits in visual-spatial skills can cause difficulties in distinguishing, connecting, and organizing information meaningfully. Incomplete mastery of number facts, weakness in calculations, inability to connect aspects of mathematical concepts, inability to transfer knowledge, difficulty making meaningful connections between information, inability to transform information mathematically, incomplete mastery of mathematical terms, incomplete understanding of mathematical language complete, and difficulties in understanding and visualizing mathematical concepts can result in difficulties in solving problems (Tambychik & Mohd Meerah, 2010). This can indirectly cause various mistakes and confusion in the problem-solving process, as happened in this study.

In this study, the informants involved gave a very positive response to the alternative method that had been introduced. The informants unanimously agreed that the Jigsaw cooperative Method helped them understand the concepts of each topic better with the expert help of their high-achieving classmates. This finding is supported by Collins et al. (1989), who said that the internalization of the Jigsaw cooperative method could be achieved through modelling, discussion and the role of students in reciprocal learning. Through discussion, learning becomes explicit, and students can gradually internalize it. In this regard, metacognitive knowledge and students' awareness of cognitive processes are given attention, such as the problem-solving steps that need to be followed and how they work, when they should be applied, and whether they are effective. According to Brand-Gruwel et al. (2005), such metacognitive knowledge and awareness are important for students to control and organize the problem-solving process. The Polya Problem Solving Model is seen to be very helpful for students to understand the questions better and be able to solve the problems given by implementing step-by-step solutions. The introduced method is also seen to be very organized with clear problem-solving steps, which can help students solve the given problems carefully and reduce any small mistakes.

Based on the findings of the study, informants are seen to be able to understand the requirements of the questions better as a result of using this alternative method in their teaching and learning in class. So with that, they can apply what they learn from this alternative method by solving long sentence problems step by step. Therefore, it is able to reduce errors in the process of solving problems. Informants can understand the requirements of the questions better, and this can be seen in the improvement in their grades or marks. Apart from that, the informant can also identify the important steps in solving this long

sentence problem. The steps that have been identified are understanding the problem, solving the problem, and revising.

Problem-solving, as used in the Mathematics Education literature, refers to the process by which students encounter problems in questions that do not have clear solutions or algorithms that they can implement directly to obtain answers (Tripathi, 2009). After being introduced to the alternative method in this study, students found that they were able to read the problem carefully, analyze it to obtain the necessary information, and check their own mathematical knowledge to identify the correct formula to help them find a solution. This process allows for the reorganization of existing ideas and the emergence of new ideas as students try to solve problems with the help of teachers and more expert friends who act as facilitators. This, in turn, helps students review their knowledge and build new relationships by asking appropriate questions. Nakin (2003) stated that problem-solving is the process of using certain steps (heuristics) to help in problem-solving. The results of the study show that most of these low-achieving students think that they can solve the problems given systematically with the help of more capable friends.

VIII. CONCLUSION

Through the findings of this study, it can be concluded that alternative methods of solving problems have helped low-achieving students increase their achievement in the subject of Introduction to Quantitative Techniques. Through the Jigsaw cooperative method and the Polya Problem Solving Model, students realize the importance of strategizing to work systematically and the guidance of classmates in solving problems. This alternative method is able to help students improve their skills in solving long-sentence problems while also obtaining better grades. However, the increase in student scores is not seen to be significant due to the limited time required to practice new skills. Problem-solving strategies through the Polya Problem Solving Model and the Jigsaw cooperative method should be taught by the instructor early before a topic is introduced to ensure students have enough skills to perform problem-solving.

There are several recommendations suggested by the researcher for improving the implementation of the study in the future. Among them is the use of a large sample from various other diploma courses. In addition, the effectiveness of students in problem-solving strategies should also consider external and internal factors that may cause students to lack problem-solving skills, such as family background, peer influence, attitude, and motivation towards learning. Future studies can also use quantitative research methods to study the combination of effective problem-solving methods in learning the subject of Introduction to Quantitative Techniques.

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