PPD Profesi Pendidikan Dasar
p-ISSN: 2406-8012 | e-ISSN: 2503-3530
PROFESI PENDIDIKAN DASAR

Impact of Attitude Category on Problem-Solving Skills: An Experiment within a Flipped Learning Model with STEM Approach

Rusnilawati Rusnilawati *[1,2], Siti Rahaimah Binti Ali [1], and Mazarul Hasan Mohamad Hanapi [1]
[1]Universiti Pendidikan Sultan Idris, Malaysia
[2]Universitas Muhammadiyah Surakarta
*Corresponding Author's email: rus874@ums.ac.id

Submitted: 2023-02-01
Revised: 2023-03-11
Accepted: 2023-04-12

DOI: 10.23917/ppd.v10i1.4267

Keywords:
attitude category; problem-solving; flipped learning; STEM approach

Abstract

This research endeavours to elucidate the notable disparities in Problem-Solving Skills (PSS) when employing the Flipped Learning Model with a STEM Approach (FLM-SA) in contrast to Routine Learning, contingent upon attitude categories. The study harnesses a quantitative methodology with a quasi-experimental design. A sample size of 210 students is utilised, chosen via cluster random sampling. The instruments for data collection comprise: 1) an attitude questionnaire; 2) problem-solving tests; and 3) an observation sheet for the execution of the learning process. The techniques for data analysis employed are both parametric and non-parametric tests. The findings unveil a significant discrepancy in the students' Problem-Solving Skills based on attitude category between the control group, post the implementation of routine e-learning, and the treatment group, post the utilisation of the FLM-SA Module. Students possessing a Medium Attitude Category in the experimental class exhibit superior problem-solving skills compared to the control class. In contrast, students with Low and High Attitude Categories do not demonstrate a significant difference between the control and experimental classes. These findings underscore the significance of differentiated learning by implementing Teaching at the Right Level. Ideally, teachers should conduct an initial diagnostic assessment to ascertain students' initial attitudes or abilities.

INTRODUCTION

Background of the Study

The increasingly rapid development of science and technology requires every human being to adapt themselves to keep up with the changes that occur and solve the problems they face carefully, precisely, and creatively. At present, technological developments lead to digital social networks and the use of gadgets (Sardone, 2018). To keep up with the demands of science and technology development, university students need to understand and train themselves to be skilled in solving problems that arise in daily life. Through the use of technology, learning can be carried out more interactively and attractively. Students can broaden their horizons anywhere and anytime with the help of internet networks and gadgets.

Online learning in Indonesia has been further enhanced following the COVID-19 pandemic to prevent the spread of the COVID-19 virus. Online learning makes it easy for educators to share material and discuss synchronously/asynchronously (Rinekso & Muslim, 2020). Besides, mathematics learning designed with the collaboration of mathematics and technology has been proven to be more effective in improving students' problem-solving abilities, attitudes, and cognitive (Sardone, 2018). In this regard, the basic mathematics concept course is one of the subjects that must be taken by students at the Primary School Teacher Training Program, Universitas Muhammadiyah Surakarta. Online learning is a learning concept being developed at Universitas Muhammadiyah Surakarta. Based on the observations and interview results with students at the Primary School Teacher Training Program, Universitas Muhammadiyah Surakarta, the e-learning process still tended to only give online assignments so that students encountered difficulty understanding mathematical concepts.

The process of learning mathematics is strongly influenced by affective factors, namely beliefs, emotions, values, and attitudes (Bishop, 2017). In order for students to be active in learning mathematics, a positive attitude towards mathematics is needed. An important aim of mathematics education is to develop in students positive attitudes towards mathematics (W. L. Ng et al., 2019). Besides, students 'attitude towards mathematics has been a factor known to influence students' achievement in mathematics (Al-Mutawah & Fateel, 2018). It is advisable that students' attitude be enhanced as this will translate into improve academic achievement in the subject (Al-Mutawah & Fateel, 2018).

The attitude domain in the teaching and learning process aims at making the students know "why". The skill domain is designed to make them know "how". Meanwhile, the knowledge domain aims at making them know "what". The final result is the improvement and balance of the ability to be good human beings (soft skills) and to be the ones having skills and knowledge to live decently (hard skills) including attitude, knowledge, and skill competencies (Umami, 2018).

Attitude is the expression or response of students regarding learning. Attitudes in the form of expressions of like, dislike, or rejecting an object (Astalini et al., 2019). The attitude towards mathematics has to do with likes and dislikes, the belief that it is good or bad, and the belief that it is useful or not. Teachers are often concerned if not frustrated, about their students' dislike or fear of mathematics (Guce, 2018). It is often considered to be an irrelevant or unpopular subject. Some efforts have been made to increase students' engagement in mathematics learning and increase their attitude toward mathematics.

Positive attitudes towards mathematics could increase academic achievement and learning (Chen et al., 2018). There is a positive relationship between students' attitudes, motivation, and discipline. Therefore, teachers need to implement the learning that fosters attitudes, motivation, and discipline of students in learning (Darmaji et al., 2019). The attitude towards mathematics has a role in learning the material. The attitude cannot be separated from teaching and learning since it is derived from the learning process. Teachers can use some pleasant learning innovations to enhance students' attitudes to mathematics (Guce, 2018). One of the innovations that can increase it is the use of technology, games, audiovisual media, video, PowerPoint, and YouTube (Higgins et al., 2017; Turkmen & Soybas, 2019).

Students' activeness will occur when the lecturers give them problems; therefore, they can develop their mindset, put forward their ideas, etc. They can think and reason a mathematics problem when they comprehend it. Their point of view on a mathematics problem also influences the problem-solving mindset that will be applied. Teachers need to instill and develop students' attitude to problem-solving as Schroeder & Lester (Jung & Newton, 2018) explains, "problem-solving is also important because it can serve as a vehicle for learning new mathematical ideas and skills." Furthermore, problem-solving skills have a significant role in supporting STEM careers (Bicer et al., 2017). Students can think innovatively and creatively when they have good problem-solving skills.

Students need to master the concept well to understand and use mathematics in problem-solving. To be able to solve the problems well, some skills are required, including understanding problems, re-expressing those they are studying, making a completion plan, reviewing the completion steps, and estimating from incomplete information (Çakıroğlu & Öztürk, 2017; Heo & Chun, 2017). Following that, as a matter of fact, the experience in solving the problems is significant to develop students' thinking skills and help them gain more skills in solving the problem in daily life (Hadi et al., 2018). Mathematics learning should refer to concrete problem observation, semi-concrete, and problem abstraction. Therefore, mathematics learning aims at making students think critically about solving the proposed problem (Umami, 2018).

Problem of The Study

The learning process of Basic Concepts of Mathematics at the Universitas Muhammadiyah Surakarta has been using an e-learning system of the Schoology and Open Learning programs. However, the e-learning process applied remains giving assignments online. Based on the survey results regarding the evaluation of the learning process in the basic concepts of mathematics in 2017, 2018, and 2019; the lowest assessment was found in learning methods and learning media. The learning methods applied were not optimal as those had not facilitated students in developing their skills in the 21st century. The learning process was still dominated by student presentation, thus problem-solving skills were substandard. Based on the observation results, the 100 minutes learning process did not cover concepts well to students. Also, students considered that the subject of basic concepts of mathematics was more difficult to learn compared to other subjects. It occurred since students encountered difficulties in understanding concepts and opted to memorize mathematical formulas. Therefore, lecturers need to incorporate innovative learning models following the information technology developments so it is easier for students to understand concepts and they are able to develop adequate skills needed in the 21st century.

Students' attitudes towards mathematics can affect learning outcomes and achievement of learning goals (Jufrida et al., 2019; Karjanto, 2017). Based on the questionnaire results, students' attitudes towards mathematics showed a fairly good category since students did not spend more time studying besides formal class (Jufrida et al., 2019). Therefore, lecturers need to prompt students' enthusiasm in learning through sophisticated IT. One of the factors that may affect students' disposition towards mathematics is instructional and social psychological environmental factors (Mazana et al., 2019). Besides, Indonesia's mathematical literacy skills are low (Afriyanti et al., 2018). The results of the 2015 PISA study show that the mathematical literacy skills of students in Indonesia were categorized as low, earning position 64 out of 72 countries (Rahmawati, 2018). Students have insufficient skills in solving math problems that require the ability to reason, argue, communicate, and solve problems. The tendency of students to access academic content through social media and the internet, such as study materials or exam questions, was under 55% (Rahmadani, 2020). Mathematical literacy skills can be improved using ICT (Indrawati, 2020). The results of several studies show that the use of ICT in mathematics learning had a positive impact on reasoning skills, mathematical communication, problem-solving, and mathematical connections (Rahmawati, 2018).

Mathematics learning in the 21st century aims to enable students to exhibit critical thinking, teamwork, problem-solving, creativity, analytic reasoning, and communication skills (Arifin, 2017). The results show that the problem-solving abilities of Indonesian students were poor (Kharisma & Asman, 2018; Bidasari, 2017). Based on the problem-solving stage, the most difficult stage for students to perform is planning and remembering. Based on the interview results, students found it most difficult the analyzing strategies to solve problems. At this stage, students must master the concepts and could not rely on formula memorization only. In the review stage, students encountered difficulty in finding a strategy to check the truth of the answers and strategies they used. Students were not used to working on problem-solving since the problems given tended to be cognitive problems with the Low Order Thinking Skill (LOTS) (Himmah, 2019; Yusuf & Widyaningsih, 2018; Suryapuspitarini et al., 2018).

Based on the test results, students still experienced problems in solving problem-solving problems. Problem-solving activities include four stages, i.e., understanding the problem, compiling a plan, implementing the plan, and reviewing it. The most difficult stage, according to students, was the stage of planning and reviewing (Suraji et al., 2018). Based on the interview results, students found it most difficult in the stage of analyzing strategies to solve problems. At this stage, students must master the concept and cannot just memorize formulas (Kurniawan et al., 2019; Novitasari, 2016; Arifah & Saefudin, 2017; Rismawati & Hutagaol, 2018). In the retrospect stage, students had difficulty revealing ways to check the truth of the answers and strategies they use. Further, the assessment of mathematics learning still tended to be cognitive assessment (Sutama et al., 2017)(Setiadi, 2016). The results showed that students' difficulties in solving mathematical problems in the form of story problems were in factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Novferma, 2016). Types of difficulties experienced by students were remembering facts, remembering concepts, understanding facts, understanding concepts, applying concepts, implementing procedures, analyzing procedures, evaluating facts, evaluating concepts, evaluating procedures, and communicating metacognitive.

A positive attitude towards mathematics has a significant role in improving student learning outcomes. Students' attitudes towards mathematics were still dominant in the relatively good and low categories, namely more than 70% (Defitriani, 2019). Anxiety in the attitude domain includes being highly careful in solving problems and taking complementary actions when students run out of ideas to solve mathematics problems that are being worked on (Rizta & Antari, 2019). Therefore, the implemented learning needs to improve innovative and creative learning strategies so that students are more enthusiastic in learning and have a positive attitude towards mathematics (Raharja et al., 2019; Sobri et al., 2020; Putrianti et al., 2017).

Research's State of the Art

Teachers are increasingly geared towards teaching in keeping with the development of 21st-century learning skills for students (Sardone, 2018). The four abilities that need to be developed in 21st-century learning include creativity, collaboration, communication, and critical thinking (Beswick & Fraser, 2019). The STEM approach contributes to the development and application of these skills through an inquiry-based learning approach. The STEM approach is designed to improve the quality of a nation's learning to excel in the fields of science, technology, economics and have the power to compete globally through systemized education. This approach connects multidisciplinary science into an integrative whole. The teacher directs students to deepen their understanding of concepts so that they can integrate theoretical understanding and skills. Therefore, the development of student skills is an aspect that is of great concern in implementing the STEM approach.

STEM is an interdisciplinary approach that directs students to use science, technology, engineering, and mathematics in the context of real problems and correlates with relevant experiences that students need in the world of work in the future (Holmlund et al., 2018). The STEM approach consists of science aspects, technological aspects, engineering aspects, and mathematics aspects. The science aspect is the skill to use the knowledge and scientific processes to understand natural phenomena and manipulate these symptoms so that they can be implemented (Martín-Páez et al., 2019). Technology aspects are students' skills in knowing how new technology can be developed, what skills to use technology, and how technology can be utilized to facilitate human work. The engineering aspect is the knowledge to operate or design a procedure to solve a problem. Meanwhile, mathematics aspects are skills used to analyze, provide reasons, communicate ideas effectively, solve problems, and interpret solutions based on calculations and mathematical data (Bicer et al., 2017).

The flipped learning model becomes a technology-based learning model that aims to increase student involvement in the learning process and make the delivery time more efficient (Zainuddin, Hermawan, et al., 2019). The flipped learning model is one of the learning innovations with the concept of e-learning (Hamid, 2020). The teacher is in charge of making materials in writing, narration, video, podcasts, and various other media that students can reach outside the classroom. Activities usually carried out in the classroom, such as explaining the material, giving assignments, question training, and homework, are transferred to online learning. Before entering the classroom, students already have several pieces of information that come from the material content studied online. Activities in the classroom are more dominant in case study activities, problem-solving, lab tests, practicum, games, simulations, and experiments (Akçayır & Akçayır, 2018). Thus, students are no longer bored and tired of listening to lectures from the teacher.

The flipped learning model application puts remembering and understanding stages as a cognitive level carried out outside the classroom by observing various material content accessed online. Learning activities in the classroom are conducted for learning at the cognitive level, namely applying, analyzing, evaluating, and creating (Zainuddin & Halili, 2016). In order for the flipped learning application to run optimally, teachers need to make several preparations, including ICT skills, online learning media (e-books, videos, recordings), adequate technology devices (computers, laptops, cellphones), and a stable internet network (video call, streaming, etc.) (Hamid, 2020). Five positive reasons for applying the flipped learning model according to Millard are (1) increasing student involvement in the learning process, (2) strengthening team performance-based skills, (3) offering an educator approaches to students personally through guidance, and (4) student activities such as class discussions become more focused (Schmidt & Ralph, 2016). The flipped learning model is beneficial for teachers who lack time in teaching material (Hamid, 2020). This learning model application is very appropriate for students who can take advantage of technology and adapt to the educational content presented by the teacher.

Gap Study & Objective

Novalinda et al. (2023) claim that flipped learning helps students to comprehend and resolve clinical refraction cases and to create a stimulating learning environment that matches their interests, which increases their enthusiasm for learning. This is supported by the research of Kardipah & Wibawa (2020), who found that using a flipped learning model in both experimental and control groups resulted in differences in problem solving and learning motivation that enhanced the performance of the computer application course. Flipped learning model affects not only the problem solving process but also students' attitudes. Bin-Hady & Hazaea, (2022) report that respondents had a favourable attitude towards the flipped pronunciation class with a mean score of 4.1045 and a standard deviation of 0.50519. This is in agreement with the research of Singay, (2020), who observed that students improved their English grammar and demonstrated positive attitude and perception towards flipped class learning.

STEAM learning encourages students to collaborate and explore problems to foster their learning development in the 21st century. With the STEAM approach, students' information literacy and comprehensive ability can be improved (Zhao & Li, 2022). Horvath et al., (2023) argue that STEAM learning aims to promote participation, imagination, and engagement in complex problems. According to the research of Ilma et al., (2023), implementing STEM integrated with CAR can enhance the attitude of exploring new things and creativity. Furthermore, the research of Silva-Hormazábal & Alsina, (2023), indicates that learning with the STEAM approach elicited a very positive attitude towards this approach, along with a moderate level of confidence to implement it. Problem solving ability influences the attitude displayed by someone. Abusamak et al., (2024) state that students who have an understanding of the topic will show a positive attitude in learning. This is consistent with the research of Habók et al., (2023), who found that students' problem solving strategies had a significant and positive impact on reading comprehension. Additionally, students' attitude towards theoretical understanding had a positive and significant effect on the use of online reading strategies and students' achievement.

The literature reveals the influence of flipped learning and STEM approach on problem-solving skills and attitude. Furthermore, some studies have also established a correlation between attitude and problem-solving skills. However, no study has investigated the variation in problem-solving skills according to attitude category. Previous research has also not implemented Flipped Learning Model and STEM Approach in combination. Hence, this study aims to explore the significant difference between Problem-Solving Skills (PSS) by applying Flipped Learning Model with STEM Approach (FLM-SA) versus applying Routine Learning based on attitude category.

METHOD

Type and Design

The research method used was the quantitative method. The type of quantitative research used was experimental. Experimental research is a method that emphasizes three conditions, namely controlling, manipulating, and observing activities (Boeren, 2017). The research design used by the researcher was quasi-experimental in the form of a nonequivalent control group design. The quasi-experimental design has a control group but cannot fully control the external variables that affect the implementation of the experiment (Mat-Roni et al., 2020). With a quasi-experimental design, the research aimed to find the effect of the Flipped Learning Model with STEM approach compared to Routine Teaching (Problem Based Learning Model with Contextual Approach). Lastly, an account of the pilot study had been included. The pilot study was used to ensure validity and reliability of the instrument used in this research.

One of the designs prescribed by the quasi-experimental design is the nonequivalent control group design. The nonequivalent control group design requires random assignment of intact groups to treatments rather than random assignment of individuals (L. Li et al., 2020). The flexible nature of nonequivalent control group design makes it suitable to be adopted for this research. In this research the two groups formed by random assignment were the Flipped Learning Model with STEM Approach and the routine teaching group. The two groups were pretested and then subjected to different treatments. After treatment, both groups were post-tested at the end of the study. The post-test scores had been compared to determine the effect of the treatment. The nonequivalent control group design is illustrated as shown in Figure 1. below.

R_1	O_{pre}	X_1	O_{post}
R_2	O_{pre}	X_2	O_{post}
Symbols :		R : Randomly assigned groups	
O	: Tests		
X_1	: Flipped Learning Model (FLM) with STEM Approach Treatment		
X_2	: Routine Teaching Treatment		

Figure 1. The nonequivalent control group design (Moon et al., 2021)

Data and Data Sources

The primary data obtained directly from the experimental trials are used as the data. The research subjects, who are students taking the course of basic mathematics concepts, are the sources of the data. The research population for this study was all students of the Primary School Teacher Training Program at the Muhammadiyah University of Surakarta. As a guide to determine the size of the sample, Dr. John Curry's 'rule of thumb' was used (Yang et al., 2019). Dr. Curry suggests that the quantum of sampling required depends on the size of the population. The appropriate sample size that corresponds to the given population size is shown in Table 1. Based on the Table 1., a sample size of 210 students, which forms 19% of the total population (1100 students), was assumed to be large enough for this research. The extraneous variables that may affect the study had been controlled. The sample comprises four intact classes and was randomly allocated as two experimental groups and two control groups for this research.

Table 1. Dr. John Curry's "rule of thumb" on sample size (Yang et al., 2019)

Size of population	Sampling Percent
0-100	100%
101-1000	10%
1001-5000	5%
5001-10000	3%
10000+	1%

Data collection technique

The instruments of this research consist of : 1) attitude questionnaire; 2) problem-solving tests; and 3) observation sheets on the implementation of the learning process. The instruments include: a questionnaire, a pretest, a posttest; and an observation sheet. The pretest for the experimental class had been applied to students prior to the implementation of the Flipped Learning Model with STEM approach. Meanwhile, the pretest for the control class had been conducted on students prior to the implementation of the Routine Learning Model. The post-test in the experimental class had been performed after the implementation of the Flipped Learning Model with STEM Approach. Whereas, the posttest for the control class will be given after the implementation of the Routine Learning Model.

Attitude questionnaire towards mathematics

The questionnaire to measure students' attitudes towards mathematics encompasses statements about students' attitudes in learning the basic concepts of mathematics. The scoring was arranged based on five rating scales; strongly agree, agree, undecided, disagree, and strongly disagree. The administration of the attitude questionnaire preceded the learning process, aiming to categorize students based on attitude classifications. The evaluated dimensions of attitude encompassed: 1)

Cognitive (knowledge about mathematics); 2) Affective (sentiments towards mathematics); and 3) Behavioral (inclination towards action). Findings from the pilot test revealed the validity of 32 items from the attitude questionnaire (sig.<0.05). Furthermore, the results of the reliability test demonstrated a Cronbach's Alpha value of 0.905, indicating high reliability.

Problem-Solving test

The effectiveness of the Flipped Learning Model with STEM Approach was viewed from the problem-solving ability test scores in the form of essays. The problem-solving ability test had been used to obtain data on the achievement of competency skills in problem-solving. The problem-solving examination was conducted through both a preliminary test (pretest) and a subsequent test (posttest). The aspects evaluated include:1) understanding the problem; 2) make a plan (see how the various items are connected, how the unknown is related to the data, to get an idea of the solution); 3) carry out the plan, and 4) look back at the solution that has been completed (then review and discuss it). The pretest consisted of two questions that underwent rigorous validation (sig. <0.05) and exhibited reliability, as evidenced by a Cronbach's Alpha value of 0.8 (indicating reliability). In contrast, the posttest was composed of five questions that were validated (sig. <0.05) and demonstrated high reliability, with a Cronbach's Alpha value of 0.85 (indicating reliability).

Data analysis

If the data obtained from an independent sample shows that it is not normally distributed, the data analysis used is a non-parametric statistical test (Cohen et al., 2018). The non-parametric equivalents of the t-test are the Mann-Whitney U test for two independent samples. After the two groups were analyzed for differences using pretest, if it is stated that there was no significant difference, then the two groups can be used as research subjects. If the two groups are stated to have significant differences, then the two groups are not recommended as research subjects, and class re-election will be carried out for the treatment (X) and control (C) groups.

Independent Comparative Test Analysis

The independent comparative test compares the mean of two unrelated samples between one variable and another (Habiby, 2017; Cohen et al., 2018). Therefore, this analytical technique tests whether the treatment groups and control groups have the same initial ability. One of the conditions that must be met before intervening is that treatment groups and control groups have the same initial ability in terms of cognitive, attitude, and problem-solving skills. Data are obtained from the results of the pretest treatment groups and control groups. If the results of the student's initial ability test are not equal, class re-election will be carried out for treatment groups and control groups. For the test results to align with expectations, the researchers test two classes using student learning outcomes in the previous material before giving students a pretest for cognitive, attitude, and problem-solving skills.

If the data obtained from an independent sample shows that it is not normally distributed, the data analysis used is a non-parametric statistical test (Cohen et al., 2018, p.794). The non-parametric equivalents of the t-test are the Mann-Whitney U test for two independent samples. After the two groups were analyzed for differences, if it is stated that there was no significant difference, then the two groups can be used as research subjects. If the two groups are stated to have significant differences, then the two groups are not recommended as research subjects, and class re-election will be carried out for the treatment (X) and control (C) groups.

Two-Way Anova Analysis (Factorial Analysis of Variance)

Based on the research objectives, which are: to compare the difference in students' problem-solving skills based on attitude category between the control group and the treatment group, it can be concluded that the appropriate analytical technique is Two Way Anova. If each sample contains two or more categories, a Two Way ANOVA will be used to test the comparative hypothesis of the K-sample average (Habiby, 2017). Factorial analysis of variance is used in research situations where two or more group membership variables (called "factors") are combined. After the intervention, this testing technique will compare the mean scores in groups X and C. The category used in hypotheses comes from the attitude scale, which is divided into three levels: low, moderate, and high. Low = X<M – 1 SD; Medium = M – 1 SD ≤ M + 1 SD; High = M + 1 SD (Cohen et al., 2018)

In a two-way factorial design, there are two main effects: one for Factor A and one for Factor B. Factorial designs also have to take account of the interaction of the the levels of two factors. The extent to which groups created by combining the levels of two factors cause changes in a dependent variable is called an A × B interaction. The criterion for accepting the hypothesis is that the null hypothesis is accepted if $P_{value} \geq 0.05$. Data analysis was conducted using Statistical Package for the Social Sciences (SPSS) Version 20, with the significance level below 0.05. If the data obtained from the independent sample is not normally distributed, the data analysis used is non-parametric statistical test (Cohen et al., 2018). The non-parametric equivalents of Two Way Anova is the Friedman test.

RESULTS

The hypothesis of the experimental study was to compare the students' PSS based on attitude categories between the control group after routine e-learning was implemented and the treatment group after Flipped Learning Model with STEM Approach was used. This was done by testing the following hypothesis using Two-Way Anova Analysis to compare the mean scores in groups X and C. Meanwhile, the non-parametric **Kruskal-Wallis test** was used to compare the median scores in groups X and C. The categories used in hypothesis were based on the attitude scale towards mathematics, which was divided into three levels: low, medium, and high.

Ho: There was no significant difference in the mean of the scores for the students' problem-solving skills based on attitude category between the control group after a routine e-learning was implemented and the treatment group after Flipped Learning Model with STEM Approach was used on Basic Mathematics Concept Course?

Analysis for research question

Was there any significant difference in the scores for the students' PSS based on attitude category between X and C?

The results in Table 3 indicated that the **students' PSS between groups** C and X were almost similar before intervention (sig= 0.461). The difference in mean scores for students' PSS based on attitude category between groups X and C after intervention was analyzed using Two-Way Anova (Table 4). The test results in Table 4 indicate that there is no significant positive difference in mean scores for students' PSS based on attitude category between groups X and C (sig=0.759). The descriptive data for students' Problem-Solving Skills (PSS) within each attitude category in Group C after implementing the Routine e-learning model and in Group X after implementing the FLM-SA Model can be observed in Table 5. Since the normality assumption for the distribution of scores was not met (Table 2), non-parametric tests were used to verify these results. Table 2 display the normality test results of students' PSS. The Mann-Witney tes results in Table 3 indicate that the students in the control and experimental groups had similar attitudes towards mathematics before the intervention. **The Kruskal-Wallis test** was used to compare median scores for students' PSS based on attitude category between groups X and C after the intervention. Table 6 shows a significant positive difference in median scores for students' PSS based on attitude category between groups X and C (sig<0.001) after the intervention. Therefore, the scores for students' PSS based on the attitude category showed a significant difference, as seen in non-parametric tests (Table 8).

After identifying a significant difference in the scores for students' Problem-Solving Skills (PSS) based on attitude categories between groups X and C following the intervention, further analysis was conducted to examine the comparisons of PSS scores between groups X and C within each attitude category (low, medium, and high). The difference in mean scores for students' PSS on each attitude categories (low, medium, and high) between groups X and C was analyzed using independent t-test. The results showed a positive significant difference of the mean scores in the medium attitude category (sig<0.001). On the other hand, the mean scores of PSS in the group of students with a low attitude category (sig=0.436) and high attitude category (sig=0.092) demonstrated equivalent results between groups X and C. The Mann-Whitney U test was used to compare the median scores for students' PSS between X and C after intervention on each attitude categories (low, medium, and high). The results showed a positive significant difference of the median scores in the medium (sig<0.001) attitude category. On the other hand, the median scores of PSS in the group of students with a low attitude category (sig=0.264) and high attitude category (sig=0.361) demonstrated similar results between groups X and C. The same results were also indicated in Table 7, which employed an independent t-test. The results showed a positive significant difference of the mean scores in the medium (sig<0.001) attitude category. On the other hand, the median scores of PSS in the group of students with a low attitude category (sig=0.436) and high attitude category (sig=0.092) exhibited equivalent results between groups X and C.

Table 2. Normality test for the mean of PSS scores before and after intervention

	Group	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
PSS Score (before intervention)	C	0.110	104	0.003
	X	0.108	106	0.004
PSS Score (after intervention)	C	0.137	104	0.000
	X	0.144	106	0.000

Table 3. Comparing the median scores for dependent variables between X and C groups before and after intervention using Mann-Witney test

Test		Median (IQR)		z-statistics	Asymp. Sig. (2-tailed)
		C	X		
attitude toward mathematics	Before intervention	120.00(10.00)	120.50(15.00)	-0.409	0.682
problem-solving skills	Before intervention	72.50(15.00)	72.50(23.13)	-0.738	0.461
	After intervention	80.00(14.00)	83.00(8.00)	-3.870	0.000

Table 4. Comparing the means of PSS scores based on attitude category between groups (C & X) after intervention using Two-Way Anova

Test of PSS Scores	df	Mean Square	F	Sig.
PSS_Attitude Category	2	510.72	6.828	0.001
Learning Model	1	634.90	8.488	0.004
PSS_Attitude Category * Learning Model	2	20.69	0.277	0.759

Table 5. Descriptive Statistics of PSS scores based on attitude category between groups (C & X) after intervention using Two-Way Anova

Descriptive Statistics

Dependent Variable: Posttest PSS

Attitude Category	Learning Model	Mean	Std. Deviation	N
Low	Routine e-learning	71.9091	8.16645	11
	FLM-SA	75.1333	11.50072	15
	Total	73.7692	10.16782	26
Medium	Routine e-learning	77.3827	9.82544	81
	FLM-SA	83.3194	6.71728	72
	Total	80.1765	8.98472	153
High	Routine e-learning	77.3333	11.02339	12
	FLM-SA	82.4211	5.14583	19
	Total	80.4516	8.17247	31
Total	Routine e-learning	76.7981	9.86352	104
	FLM-SA	82.0000	7.78766	106
	Total	79.4238	9.23103	210

Table 6. Comparing the medians of PSS scores based on attitude category between groups (C & X) after intervention using **Kruskal-Wallis Test**

Test of PSS Scores	df	Asymp. Sig
Attitude category	2	0.005
Learning Model	1	0.000
Attitude category * Learning Model	5	0.000

Table 7. Comparing the means of **PSS scores based on attitude category** between groups (C & X) after intervention using independent t-test

Attitude Category	Mean (SD) of PSS		t-statistic (df)	Sig. (2-tailed)
	C	X		

Low	71.91(8.16)	75.13(11.50)	-0.793 (24)	0.436
Medium	77.38 (9.83)	83.32(6.72)	-4.309(151)	0.000
High	77.33 (11.02)	82.42 (5.14)	-1.745(29)	0.092

Table 8. Comparing the medians of **PSS scores based on attitude category** between groups (C & X) after intervention using Mann-Whitney U test

Attitude Category	Median (IQR) of PSS		Z-statistic	Asymp. Sig. (2-tailed)
	C	X		
Low	74.00(13.00)	76.00 (19.00)	-1.117	0.264
Medium	80.00(14.50)	85.00 (8.00)	-3.730	0.000
High	79.00(18.00)	82.00(5.00)	-0.914	0.361

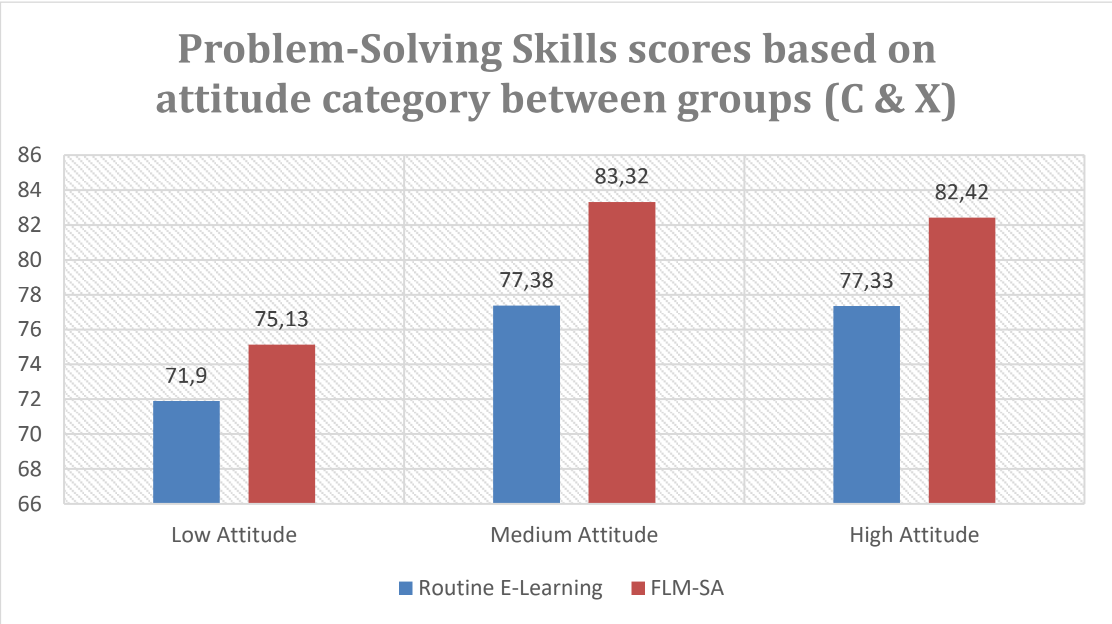

Figure 2. Problem-Solving Skills scores based on attitude category between groups (C & X)

From the analysis of the data collected for students' PSS during the research it was found that:

There wad a significant difference in both the mean and median scores for the students' PSS-based on attitude category between the control group, after routine e-learning was implemented, and the treatment group, after Flipped Learning Model with STEM Approach was used on Basic Mathematics Concept Course. The FLM-SA Model group performed better PSS scores than the routine e-learning group among students with a medium attitude category. **Thus, H_0 was rejected.**

DISCUSSIONS

The research findings indicate a noteworthy disparity in problem-solving skills based on attitude categories (low, medium, and high). Through statistical analysis, it becomes evident that the implementation of the FLM-SA Model exerts a significant influence on the problem-solving skills of students falling within the medium attitude category. Conversely, this study highlights that the FLM-SA Model fails to yield a significant impact on the problem-solving skills of students with low or high attitudes. Notably, students displaying a medium attitude constitute a larger contingent, comprising approximately 73% of all respondents. Consequently, it can be deduced that the FLM-SA Model holds promise for enhancing problem-solving skills.

For students exhibiting a high inclination toward mathematics, it is advisable to administer more demanding problem-solving tasks, given their heightened enthusiasm for the subject. It is imperative for educators to grasp the idiosyncrasies of their students in order to provide tailored and meaningful learning experiences. The research findings underscore the rich diversity in student characteristics, a factor that can exert a considerable influence on the efficacy of the learning process (Ashrafi et al, 2022; Guo et al, 2020).

Initial diagnostic assessment is a process of evaluating the areas of difficulty that learners have in acquiring certain knowledge, so that learning can be tailored to their abilities and circumstances. Initial diagnostic assessment is crucial because it enables teachers to design effective and efficient learning strategies that suit the students' needs and potential. By using initial diagnostic assessment, teachers can adapt the content, method, media, and evaluation of learning to the students' attitude category. This can enhance the students' motivation, participation, and learning outcomes. Moreover, initial diagnostic assessment can also assist teachers in identifying students who require special support, so that teachers can take proper measures to improve their problem-solving skills.

Teaching at the Right Level (TaRL) is a learning approach that focuses on improving students' basic skills in numeracy and literacy. This approach is based on the philosophy of Ki Hadjar Dewantara, who prioritised the interests and readiness of students, rather than just grade levels. In the TaRL approach, teachers conduct an initial assessment to determine the level of understanding and readiness of students in learning the designed materials. Then, teachers group students based on the same level of readiness, and provide materials that match their abilities. The TaRL approach has proven effective in enhancing students' learning outcomes.

Based on previous research findings, it is evident that an individual's attitude toward mathematics can significantly impact their problem-solving skills (Bicer et al, 2019; Kurt & Benzer, 2020). However, prior studies have predominantly focused on analyzing the relationship between attitude and problem-solving skills (Albay, 2019; Sırakaya et al, 2020), with limited exploration into how students' problem-solving abilities vary across attitude categories, namely low, medium, and high. Problem-solving skills hold a paramount position in modern education, equipping students to confront both present and future technological advancements (Ahmad et al, 2019). Consequently, it becomes imperative to foster a positive attitude toward mathematics among students (Du et al, 2022). Such a positive disposition not only serves as a motivating force for students in tackling non-routine problems but also encourages the utilization of diverse problem-solving strategies. To empower students to excel in problem-solving tasks, nurturing self-confidence in collaborative work and instilling a belief in the practical applicability of mathematics in everyday life becomes indispensable.

Enhancing the problem-solving prowess of students exhibiting a low attitude toward mathematics presents itself as a challenging yet rewarding undertaking. Educators must exemplify the real-world relevance of mathematical concepts pertinent to elementary education (Ijebor et al, 2022). By elucidating the intricate ties between mathematics and future career prospects, students may find renewed motivation for learning. The implementation of the FLM-SA Model in teaching and learning not only encourages active engagement but also fosters group discussions centered around problem-solving. Such an approach renders the subject of mathematics more interactive and enjoyable for students.

In the context of mathematics, it is crucial for educators to recognise and address each student's strengths and weaknesses, tailoring their teaching strategies accordingly (Alamri et al, 2021). Furthermore, students should receive additional support or challenges tailored to their specific needs. The FLM-SA Model incorporates visual aids, diagrams, and multimedia to render mathematical concepts more accessible and less daunting. Throughout the Flipped Learning process, teachers should acknowledge and commend students for their endeavours and advancements within the Open Learning setting. Cultivating a positive classroom atmosphere can significantly bolster students' self-assurance.

There are several strategies that can be implemented to enhance problem-solving skills among students, irrespective of whether they possess low or high attitudes: 1) Pairing students with a greater aptitude for mathematics with those who may be grappling with the subject. This fosters a conducive peer learning environment. 2) Presenting mathematical challenges that are relevant to everyday scenarios and allowing students to collaborate in devising solutions. 3) Encouraging students to deconstruct intricate problems into more manageable steps. The level of complexity can gradually escalate as students gain confidence. 4) Providing supplementary resources, such as online tutorials or worksheets, within the Open Learning environment. 5) Motivating students to view challenges as opportunities for personal growth rather than perceiving them as failures. Students should be instilled with the belief that diligence and perseverance are fundamental to progress. 6) Incorporating mathematical games and puzzles into the curriculum to make learning an enjoyable experience while simultaneously enhancing problem-solving skills. 7) Furnishing clear and concise instructions for assignments within the Open Learning platform, particularly those pertaining to problem-solving tasks. It is imperative to underscore that cultivating a positive disposition towards mathematics is as pivotal as honing one's problem-solving abilities (Alam et al, 2023; Putra et al, 2021). Patience, encouragement, and a supportive classroom ambience are instrumental in assisting students in overcoming their mathematical challenges.

Flipped Learning can positively influence students' attitudes toward mathematics. By providing early access to mathematical content, students can adequately prepare themselves and overcome any fears associated with the subject. They have more time in class for discussions, posing questions, and receiving direct guidance from the teacher (Kay et al., 2019). This enhances their confidence in understanding and mastering mathematical concepts, subsequently fostering a positive attitude toward the subject. In flipped learning, students must take the initiative to independently comprehend mathematical material before entering the class. This autonomy instills confidence in them as they control their learning process. The sense of achievement derived from this autonomy contributes to a more positive attitude toward mathematics.

When students prepare in advance, they have more extended periods to digest complex mathematical material. This can alleviate anxiety or fear related to this subject. Upon entering the class, they may be better prepared to face challenges and questions related to mathematics. In class sessions focused on discussion and collaboration, students have the opportunity to directly ask the teacher or engage in discussions with peers about mathematical concepts they might not fully understand. This aids in overcoming comprehension barriers and enhances interest in mathematics. In flipped learning, students are often assigned tasks or projects involving the application of mathematical concepts in real-world contexts (Lo et al., 2017). This can help students perceive the relevance and utility of mathematics in their daily lives, potentially increasing motivation and fostering a positive attitude toward the subject.

The STEM Approach can also positively influence students' attitudes toward mathematics. This approach connects mathematics with real-world applications in science, technology, engineering, and mathematics. It makes students aware of the relevance of mathematics in everyday life and in solving broader problems (Priemer et al., 2020). By viewing mathematics as a useful tool in exploring science and technology, students can develop a more positive attitude toward this subject. When students

PRINTED ISSN 2406-8012

understand how mathematics is employed in scientific and engineering projects, they tend to cultivate a more positive attitude toward the subject.

STEM promotes problem-solving and the resolution of complex tasks. When students engage in activities like these, they perceive mathematics as a useful tool for understanding and solving problems. This can enhance their confidence in facing mathematical challenges. The STEM Approach often involves teamwork, where students with diverse backgrounds collaborate to complete tasks. In this context, mathematics frequently becomes the language used for communication and collaboration. This helps students see the social and collaborative aspects of mathematics, making it more engaging and influencing their positive attitude.

CONCLUSION

Among the student groups categorized with moderate attitudes, a significant difference is observed in problem-solving skills. These results underscore the positive impact of the FLM-SA Model on mathematics learning. Conversely, students with low and high attitude categories do not demonstrate significant differences in problem-solving aspects. These findings imply that teachers should allocate more attention, particularly to students with low attitude categories. Therefore, teachers are encouraged to conduct initial diagnostic assessments to tailor appropriate teaching strategies based on the diverse abilities of students. The scope of the research findings is somewhat limited, given that the materials employed are solely focused on the subject of fundamental mathematical concepts. Additionally, this study primarily concentrates on the categories of attitude and problem-solving skills. As such, it is recommended that future research should incorporate other variables, for instance, cognitive or collaboration skills. The FLM-SA model could potentially be expanded by utilising a range of digital and non-digital media. The results of the research highlight the critical role of differentiated learning. It is suggested that teachers should ideally formulate learning plans by applying the concept of Teaching at The Right Level. As a result, students can maximize their learning outcomes as they receive instruction tailored to their specific needs.

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