Macrothink Institute™

Journal of Educational Issues
ISSN 2377-2263
2022, Vol. 8, No. 2

Improving Mathematical Problem-Solving Abilities by Virtual 5E Instructional Organization

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Received: July 21, 2022 Accepted: August 17, 2022 Published: August 25, 2022

doi:10.5296/jei.v8i2.20099 URL: https://doi.org/10.5296/jei.v8i2.20099

Abstract

The purpose of this action research was to improve mathematical problem-solving abilities using the virtual 5E instructional organization for undergraduate math students who required to pass the criteria of 70% of the full score. This study involved thirty undergraduate math students from one university who were enrolled in mathematical problem-solving courses for mathematics teachers during the first semester of academic year 2021. They were randomly chosen using cluster random sampling. There are three types of tools utilized in this research: 1) a plan for mathematical problem-solving abilities, 2) an assessment of problem-solving abilities in mathematics, and 3) a student behavior observation form. The statistics used in the data analysis are descriptive for calculating mean, standard deviation, and percentage. The finding showed that mathematical problem-solving abilities had been achieved. Undergraduate students in mathematics had average scores of 35.00, 46.07, and 50.19 after completing learning activities in the first, second, and third cycle, indicating 58.33%, 76.78%, and 83.65%, respectively. In the second and third cycle, all students achieved 70% of the entire score. The findings shows that experienced undergraduate students can solve mathematical problems as a proportion of the overall score when using the virtual 5E instructional organization.

Keywords: Action research, Inquiry-based learning, Mathematical problem-solving abilities

1. Introduction

1.1 Introduce the Problem

Learning management is based on the 21st century learning framework to encourage learners to develop skills that match the demands of a changing society. In general, the emphasis is on 21st-century learning and innovation abilities, such as: critical thinking and problem solving, communication, collaboration, and creativity and innovation (Chiruguru & Chiruguru, 2020) as well as the ability to use technology correctly (Jaroensa & Sengsri, 2020; Phoodee, 2021). The management of learning in the twenty-first century differed from previous centuries, when students relied on education to communicate science from the instructor’s experience or to read books and textbooks. The instructor’s role necessitates a method that can teach the learner how to build all-round learning skills, integrate accessible knowledge to benefit themselves and society (Collins & Halverson, 2018; Dachakupt & Yindeesuk, 2014) solve problems utilizing intelligence, and function normally in the real world (Tuntirojanawong, 2017).

1.2 Importance of the Problem

The Ministry of Education and the Ministry of Higher Education, Science, and Innovation announced the closure of educational institutions, which has had a variety of consequences for graduates. Whether anxiety, socialization, or health can be altered, schools must protect students from diseases in a variety of ways, including the use of masks. Avoid going to crowded areas as well as social isolation. To reduce the spread of COVID-19, some establishments have suspended work or have professionals work from home (Marome & Shaw, 2021; Phanchamlong et al., 2022). Student-centered approach for learning and teaching that emphasizes students with 21st century skills including analytical thinking, advanced thinking, digital intelligence, and teamwork abilities (Dostal et al., 2017; Nuangchalerm et al., 2020). It also is crucial to have knowledge of social and global dynamics, technology, media literacy, and cross-cultural competencies. Become involved in the development of the teaching profession. The objective of the mathematical problem-solving course for math teachers is to support students in solving mathematical problems by providing them with assistance on issues like problem definition and type, problem-solving and problem-evaluation strategies, problem-solving investigation, and ability to solve problems.

1.3 The 5E Instructional Organization and a Virtual Classroom

The 5E instructional model (Bybee & Landes, 1990) is based on cognitive psychology and constructivist learning theory. The 5E instructional model is inquiry-based learning that enables learners to use the knowledge-seeking process as a reasonable step toward finding answers for themselves. It also improves skills and mathematical processes and is an important part of being instrumental in completing mathematics learning. It consists of five steps: step 1 engagement is introduced into a lesson through the use of interesting situations or activities. Instructors use questions to pique students' interest. Take it all the way to the point of learning, step 2 exploration is the understanding of the issues of interest to study and then the planning of surveys to collect data through self-experimental practices, step 3 explanation is the analysis of the survey data and its transformation. Summarize and communicate the results in various different ways, step 4 elaboration is the application of knowledge developed in collaboration with the original knowledge or conclusions used to describe other events, and Step 5 evaluation is an assessment of learning that includes thought modeling activities to determine the learner's level of knowledge (Duran & Duran, 2004). The model can be the organizing pattern of a sequence of daily lessons, individual units, or yearly plans (Panasan & Nuangchalerm, 2010; Tongco et al., 2019). In addition to the 5E educational model, digital tools that may be used on computers or mobile devices and accessed via an internet connection are used to communicate via text messages. Images, sounds, and videos enhance many areas of learning, which also improves the effectiveness of instruction and helps to address underlying problems or student backgrounds. The instructors' abilities to access knowledge as well as their information-presentation skills (Kongmanus, 2018).

A virtual classroom (Liew et al., 2020) is an online learning environment in which educators and students learn together in real time and face-to-face but from different locations via the Internet networks. The virtual classroom is accessed via various applications that provide content to learners in a variety of formats, such as alphabetical information, audio, images, animations, videos, games, quizzes, or multimedia (Seufert et al., 2022). Because of the COVID-19 pandemic, virtual classrooms have become the new standard in the education industry, whether in kindergarten or higher education. Technology is an important component in moving content and learner teaching forward (Nuangchalerm, 2020). Communication between educators and students allows for the control, sequencing, and facilitation of learning for students. The ability of virtual classrooms to allow remote learning is one advantage of using them in educational contexts. Collaborating in an online learning environment can improve academic performance (Sornsiriwong, 2021).

1.4 Summarize the 5E Instructional Organization and a Virtual Classroom

Organization of instruction which use virtual classrooms and an educational style that incorporates technological tools to teach mathematical problem-solving. It's crucial to create a learning environment that enables students to learn whenever they want and from wherever they are as a result. However, the 5E instructional model of influencing the urge to teach is integrated so that students can learn by creating new information and logically solving mathematical problems as a step through the exploration process, observe, forecast, forecast using digital tools and virtual classrooms, monitor, explore, and link self-generated information that is composed of 5 steps: step 1 engagement, step 2 investigation, step 3 explanation, step 4 elaboration, and step 5 evaluation. All of this encourages an environment of lifelong learning by giving students a variety of resources they may use both inside and outside of the classroom to develop their mathematical problem-solving abilities.

1.5 Hypotheses

Determining students' abilities toward the 5E instructional model in a virtual classroom without having them participate in face-to-face physical class activities is crucial. The research is aimed at improving mathematical problem-solving abilities to pass the criteria of 70% of the full score by virtual 5E instructional organization.

2. Method

This is an action research study based on the Kemmis and McTaggart (1988) framework, with four stages: planning (P), action (A), observation (O), and reflection (R). The workshop research fundamentals, which included three cycles were used by the researchers to conduct the research.

2.1 Participants

Population consisted of all undergraduate math students at one university in northeast Thailand who were enrolled in the MPSMTC (Mathematical Problem Solving for Mathematical Teachers Courses). Sample was selected by the cluster sampling method and consisted of 30 students who were enrolled in MPSMTC during the first semester of academic year 2021. The research variables were as follows: 1) the independent variable, the virtual 5E instructional organization, and 2) the dependent variable, mathematical problem-solving abilities.

2.2 Research Instrument

(1) The virtual 5E instructional organization in the MPSMTC consisted of six plans, each of which was quality-checked by three experts. The experts' assessment of the learning management activities yielded an average score of 4.54, indicating that they were at the most suitable level.

(2) Regarding inquiry-based learning the 5E instructional model with digital tools via a virtual classroom in each circuit, the assessment of mathematical problem-solving abilities is performed. Each cycle consists of fifteen subjective questions, with a full score of 60 points

and a five-level rating scale (4 = A plan that could lead to a correct solution with no arithmetic errors, 3 = Substantially correct procedure with minor omission or procedural error, 2 = Substantially correct procedure with minor omission or procedural error, 1 = Totally inappropriate plan, 0 = No attempt) (Kubiszyn & Borich, 2016). The mathematical problem-solving abilities test were qualified by three experts IOC values ranging from 0.67 to 1.00, difficulty from 0.46-0.75, discriminant indices from 0.33-0.84, and Pearson's correlation coefficient at 0.94.

(3) The behavior observation form is used to observe student and related to student behavior over time and design both traditional and online learning activities. The aspects of mathematical problem-solving behavior are used to generate behavioral observations involve five steps: engagement, investigation, explanation, elaboration, and evaluation. The calculation revealed that the consistency index between the question and the observed behavior ranged between 0.67 and 1.00.

2.3 Data Collection

This research was action research employed by Kemmis & McTaggart (1988). Data collection consisted of 4 steps: plan, act, observe and reflect implemented in three cycles. More details can be described in the following (Figure 1).

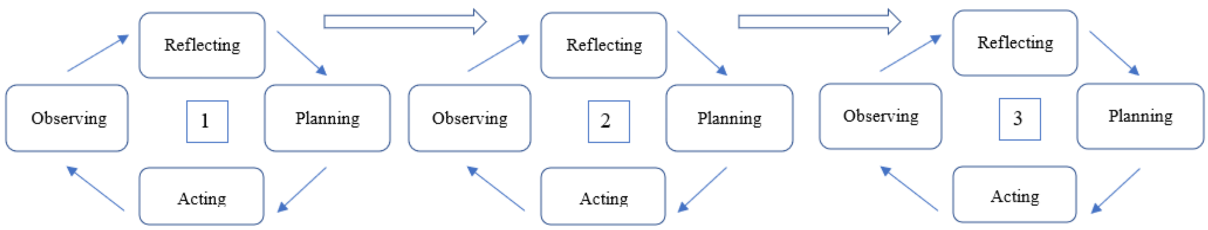

Figure 1. Steps of action research

Plan: Begin by surveying students' contexts and problems by observing the learning environment and their study behavior. The document is then analyzed, which is related to mathematical problem solving for mathematical teachers. As a result, research tools were created and developed.

Act: After constructing and improving the research instruments, Cycle 1 were used lesson plans 1 and 2. Cycle 2 were used lesson plans 3 and 4. Cycle 3 were used lesson plans 5 and 6 to implement them to the target students as follows:

Cycle 1: Using technology and virtual classrooms, researchers did the 5E in 5 steps. Step 1: generating attention and comprehending the nature of the issue. Different types of problem-solving and problem-evaluation techniques. Among the digital tools are Nearpod, Mathplayground, and YouTube. Step 2: research and identify online resources including YouTube, Mathplayground, and Linktree. Step 3: explain and draw a conclusion. Online resources like Jamboard, Google Slide, and Canva. Step 4: increase knowledge digital technologies including Jamboard, Google Slide, Canva, and step 5: Quizizz, Google Form, and Booklet are being evaluated.

Cycle 2: Through the use of digital tools in virtual classrooms, the researchers attempt to more efficiently organize knowledge-based learning activities. Create curiosity about looking for information from reputable reference sources in step 1. Searching for research papers connected to solving mathematical difficulties in areas of interest uses digital resources like YouTube, Word, Google Docs, WEB OPEC, and Eric, among others. to help students understand the issues and significance of research into mathematical solutions. Step 2: explore and search, have students watch installation videos, let them use Zotero programs to study from papers, and use digital tools like Zotero, Microsoft Word, Jamboard, Google Slide, and Canva to find research about GeoGebra and Desmos with an emphasis on APA Style references. Step 3: Describe and draw conclusions. Digital tools like Jamboard, Google Slide, and Canva allow students to study independently from information sources outside of textbooks, including using mobile devices to conduct knowledge searches. Steps 4 and 5 involve evaluating digital tools like Google Form, Google Classroom, Desmos, and GeoGebra. Step 4 involves broadening knowledge and applying existing information to solve problems in novel scenarios.

Cycle 3: The researchers have been working to improve the organization of knowledge-based learning activities. With digital tools through virtual classrooms as before, and also focus on step 1, step 2, explore and search, step 3, explain and draw conclusions, and step 5, assessment stage, as in operation cycle 2, but it increases the importance in step 4, the expansion stage includes Gather Town, Desmos and GeoGebra, by having each member of that group study the knowledge of activities on Gather Town and then exchange the learning and comments within the group itself and find conclusions that will be the knowledge of the group and afterwards, each group shares its information with the other groups, encouraging the learner to defend their positions rationally and preparing them to check their own answers for accuracy, and then the groups come to a conclusion. Both general knowledge and classroom knowledge are used.

Observe: The targeted group’s actions that suggest a capacity for applying mathematics to solve problems. It organized behavioral research. The researchers gathered score information on the targeted students’ capacity for solving mathematical problems at the conclusion of cycles 1, 2, and 3. Investigators will watch throughout learning activities and math problem-solving courses for math teachers. In order to represent the outcomes of each operational cycle and store the data for the target audience, the target student from the work sheet, the activity sheet, recorded it in a behavioral observational form.

Reflect: Information from tests, observations, and student notebooks was used. The observations received a comprehensive examination for the investigation’s objectives. The data and conclusions drawn from observing and speaking with the target students highlighted problems with the teaching and learning process. The next cycle of study results in the discovery of the rules for problem solutions.

2.4 Data Analysis

The data was collected using a test that assessed mathematical problem-solving abilities, then analyzed using basic statistics such as mean, percentage (percent), and standard deviation (SD), and then compared to the predefined criteria. Observe student behavior and use a behavior observation form to evaluate, interpret, and summarize information. Next, a comprehensive discussion of the results is required.

3. Results

The organization of inquiry-based learning activities with digital tools through virtual classrooms for undergraduate students in mathematics has improved their mathematical problem-solving abilities according to data from tests of mathematical problem-solving abilities. Each operating cycle is described in depth as indicated in Table 1.

Table 1 Mathematical problem-solving abilities score in three cycles

Cycle	Mean	SD	Percent	Interpret
1	35.00	7.91	58.33	Not Passed
2	46.07	2.68	76.78	Passed
3	50.19	9.94	83.65	Passed

Table 1 shows the results of inquiry-based learning activities delivered via digital technologies in virtual classrooms, including scores on mathematical problem-solving abilities. When comparing the percentage of average scores to the requirements for cycle 1, students' average score was 35.00 (58.33%). It was determined to be under the cutoff. When calculating the percentage of average scores compared to the threshold for cycle 2, students had an average score of 46.07 (76.78%). When comparing average scores to the criterion, students' average score for the cycle 3 was 50.19 (83.65%). In the second and third cycle, all students achieved 70% of the entire score. It was determined to be at a proficient level, demonstrating that after participating in inquiry-based learning activities, students had improved levels of mathematical problem-solving abilities as shown in Figure 2.

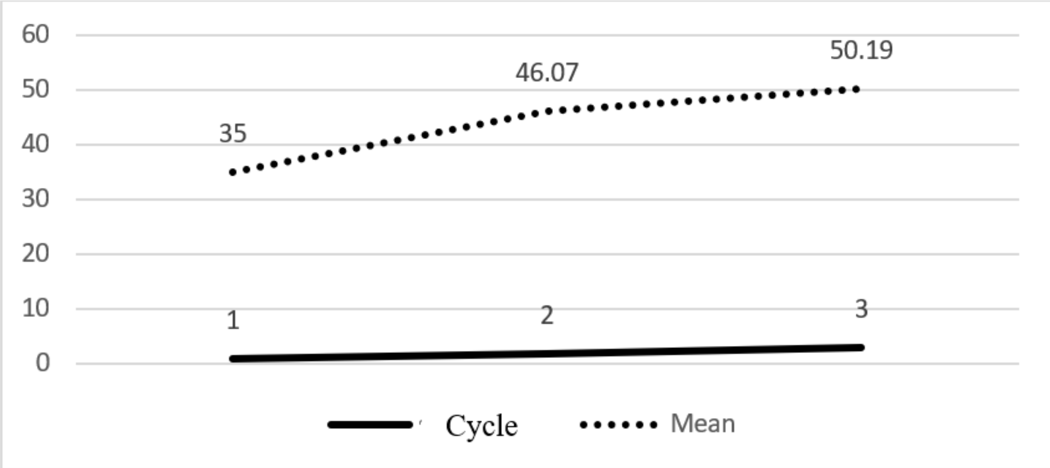

Figure 2. Mathematics problem solving abilities score

4. Discussion

The research of the virtual 5E instructional organization, which improves students' mathematical problem-solving abilities to achieve the acceptable 70 percentage of the overall score, produced results that were compatible with their intended objectives. This may be because organizing inquiry-based learning activities allows learners to have a systematic problem-solving process in stages, resulting in students being able to write accurately explaining how to solve problems that are consistent with the results of Pinmun et al. (2015) and Tunnala et al. (2011) found that students had skills with mathematical problem solving skills above the 70 percent threshold, possibly due to the provision of knowledge-based learning activities, which managed to learn to use rational systemic processes to create self-knowledge that generated understanding and were able to apply their knowledge to solve problems in everyday life based on the theory of enhancing knowledge that learners created knowledge on their own, not just receiving information, with knowledge formed by interpreting the meaning of the experience gained (Dachakupt & Yindeesuk, 2014; Thangjai & Worapun, 2022). This is supported by Suckoo and Ishizaka (2021) evaluation of students' mathematical problem-solving abilities at the beginning and increasing levels. Because problem-based learning management encourages learners to solve problems by taking action, seeking self-mobilizing knowledge, brainstorming to organize ideas until they understand the problem, developing problem solving skills with consequences that are similar to knowledge-based learning management, and managing classes through virtual classrooms by adopting learning management tools that allow learners to learn either in the classroom or outside the classroom to help facilitate learning combined with inquiry-based learning management (Schallert et al., 2020; Thangjai & Worapun, 2022). Instructors facilitate the creation of teaching activities. Collaboration communication between students and teachers managing and sequencing learning and enhancing mathematics learning and instruction, including Step 1: Increase interest in digital tools such as YouTube, Mathplayground, Nearpod, Google Docs, WEB OPEC, and Eric. Step 2: Investigate and search for digital tools such as YouTube, Mathplayground, Linktree, Google Docs, WEB OPEC, and Eric. Step 3: Explanation and conclusion Zotero, Microsoft Word, Jamboard, Google Slide, and Canva are examples of digital tools. Step 4: Extend the understanding with digital tools such as Jamboard, Google Slides, Canva, Gather Town, Desmos, and GeoGebra. Step 5: Evaluate digital tools such as Quizizz, Google Forms, and Booklet as virtual classrooms that enhance math education and make learning less monotonous, as well as have much more fun studying.

Instructional organization was carried out through behavioral observations, which the researchers utilized workshops to solve problems and develop them, by observing the behavioral capacities of the students to solve mathematical problems in each cycle. Each student behavioral cycle consists of the following 5 steps: 1) Engagement, for instance, expression, question things, showing attention in the lesson, demonstrates their own point of understanding in their answers to queries. 2) Investigation, for instance, or expressive conduct performs actions, produces predictions, and creates hypotheses or generalizations, exchanges ideas while suspending judgment, reports findings and/or generalizations, explains possible possibilities, 3) Explanation, such as expressive acts, explaining, defining, and asking makes use of earlier observations and findings, answers questions in a reasonable manner, 4) Explanation, such as expressive conduct new terminology and definitions, uses prior knowledge to investigate, elicit facts, and make conclusions that are reasonable, offers logical conclusions and remedies, outlines findings, justifications, and remedies, and 5) Evaluation, for instance, or expressive conduct, demonstrates knowledge of concepts and abilities, evaluates their own development, offers responses to open-ended questions, and provides appropriate responses and explanations to events or phenomena. This will lead to changes, such as maximizing the benefits for the student, teaching and learning are continually improved in all activities, and also include information about their own organizational processes. To improve teaching and learning even further (Sorensen & Robertson, 2020). The problem can then be resolved and developed in accordance with the objectives through reflection and an operational cycle. Researchers observed that students performed well in the first cycle. The average problem-solving capacity is 58.33 % when the full-score cutoff is less than 70%. As a result, students still don't comprehend the event's various phases. Additionally, several the individuals did not exhibit the behaviors connected to solving mathematical issues, which were discernible from the results of tests and models used to evaluate one's capacity for doing so. Examine how the students behave some might not be adept yet and receive lesser grades, while others might not be motivated to take part in activities that will help their peers. In the second and third cycle, all students achieved 70% of the entire score. After the first cycle of the teaching processes clarifies it and places the learner in a more relatable scenario, it is impossible to bring up the subject again. When presented with intriguing problems, students are more motivated to learn, research, and study, which enhances their learning (Harackiewicz et al., 2016). Practicing knowledge research and synthesizing knowledge on their own frequently and continuously. That ability and skill will become even more proficient (Cullen et al., 2018).

5. Conclusion

By studying the effects of inquiry-based learning management with digital tools through virtual classrooms to solve mathematical problems, for undergraduate students in mathematics, it can be concluded that students who have been organizing inquiry-based learning activities with digital tools through virtual classrooms can be concluded. There has been an improvement in mathematical problem-solving abilities and academic achievement in each cycle, respectively. Additionally, after implementing all learning management strategies, all of the students who were targeted achieved academically at a level that pass the criteria of 70 percent of the full score, which meets the objectives of the research, general recommendations 1) In managing knowledge-seeking learning with digital tools through virtual classrooms to solve mathematical problems, there is a process of teaching and learning, an activity that allows students to take part in researching and building knowledge for themselves. Sometimes when doing activities, the time spent on activities is insufficient, so the instructor must plan the time to do the activity in accordance with and fit the time available. 2) Using online courses and digital tools both learners and instructors need to be familiar. It should be encouraged and used by instructors before engaging in activities. Keep track of student concerns and reach out as necessary. 3) To plan lessons that challenge students to practice problem-solving techniques. To answer issues well and choose the appropriate math knowledge, instructors should promote a collective mathematical attitude among their students. Recommendations for further study 1) Should study research on integrating inquiry-based learning management with educational technology or comparing inquiry-based learning management or with other teaching styles 2) Should experiment with virtual classrooms, create learning activities, be able to learn at any time, even not in the classroom.

Acknowledgements

This research is financially supported by Kalasin University, Thailand.

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