IMPLEMENTATION OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE IN EFFORTS TO IMPROVE MATHEMATICAL ABILITIES

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Abstract. The purpose of this research is to determine: the implementation of Technological Pedagogical Content Knowledge (TPACK) learning design in efforts to improve students' mathematical abilities. The research method used is Classroom Action Research (CAR) with the Jhon Eliot model conducted in three cycles. The research sample consisted of 22 students in class IVA. The results obtained from the research are as follows: The mathematical abilities results in cycles I, II, and III show that the percentage of students who obtained grades A and A- is 18.18%, 54.55%, and 77.27%. Therefore, based on the research results, it can be concluded that the implementation of TPACK learning design can improve students' mathematical abilities

1 Introduction

The findings in the field underlie this research. The first finding was that the teaching design was solely focused on assessing students' learning outcomes, neglecting the mathematical skills aspect, thus requiring innovation in teaching. The second issue was that the mathematical abilities of some students taking the linear programming course were categorized as insufficient, resulting in unmet learning objectives. The third issue was the implementation of the Merdeka Belajar Kampus Merdeka (MBKB) in the odd semester of the 2022-2023 academic year at IAIN Palopo, where Lecturer were still struggling to create innovative teaching methods and incorporate technology in line with the digital era's advancements.

Ministry of Education and Culture Regulation No. 22 of 2016 explains that educators must possess four competencies: professionalism, pedagogical, social, and personality. Pedagogical competency requires educators to utilize communication and information technology to enhance learning effectiveness and efficiency.[1] To achieve the learning objectives of the Linear Programming course, the use of technology to facilitate the learning process is essential, necessitating the development of a Technological Pedagogical

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Content Knowledge (TPACK) instructional design. One example is the use of the Geogebra application to determine solution areas for linear programming problems.

Based on the identified issues, the instructor-researcher will design and implement TPACK-based learning as an alternative to address the three aforementioned problems, specifically in the Linear Programming course. These activities depict the use of technology to enhance learning.[2]

In fact, TPACK-based learning can enhance conceptual understanding.[3] In fact, TPACK-based learning can enhance conceptual understanding.[4] Conceptual understanding and problem-solving skills are integral components of mathematical proficiency. Additionally, other mathematical skills related to TPACK-based learning include reasoning, mathematical communication, mathematical connections, and representations. Educators must be creative and proficient in TPACK-based learning, as it not only equips them with pedagogical and content knowledge but also integrates technological knowledge into the teaching process This implies that educators must have the skills to use technology to design learning according to the needs and curriculum in place.[5] Higher education curricula are not merely a collection of courses but a set of teaching and learning processes aimed at achieving learning outcomes, ensuring effective learning, and facilitating the educational process. Curricula have standards and guidelines for determining the educational objectives of each university to produce competent graduates capable of thriving in the workforce.

In 2019, Minister of Education and Culture Nadiem Makarim introduced MBKM (Merdeka Belajar-Kampus Merdeka). The MBKM program encourages students to have strong literacy, competence, and good character to adapt to social changes, the job market, and the digital era.[6] The MBKM policy grants students the freedom to choose fields aligned with their interests and talents, allowing them to develop their knowledge and potential. Higher education institutions need to prepare and execute learning processes that encompass cognitive, affective, and psychomotor aspects to ensure students achieve learning objectives. One of an instructor's responsibilities is designing the implementation of learning, which is a crucial component of knowledge transformation to students.

Lecturer must select teaching approaches that encourage student participation and activity while ensuring that technology is used skill fully. The chosen teaching approach must also support the MBKM objectives in terms of course learning outcomes. Therefore, syllabi, RPS (Lesson Implementation Plans), and SAPs (Teaching Implementation Plans) should reflect the use of TPACK approaches and comply with MBKM regulations. Similarly, modern technology, such as computer applications or android applications, should be employed to develop teaching materials. Given this phenomenon, it is necessary to conduct research on the Implementation of technological pedagogical content knowledge in efforts to improve mathematical abilities.

2 Method

2.1 Research approach

The research approach used in this study is a quantitative approach with Classroom Action Research (CAR) as the research type. This research follows the John Eliot model of classroom action research, consisting of 3 to 5 cycles depending on the desired objectives. This study is planned for 3 cycles, with Cycle II and Cycle III serving as improvements from Cycle I.

2.2 Research subject and object

The research subject consists of third-semester students of the Mathematics Education Study Program at IAIN Palopo for the Academic Year 2022-2023. The study selected 22 students from class IIIA as the research object. The sampling technique used is purposive sampling

2.3 Research phases

The research phases are designed as follows:

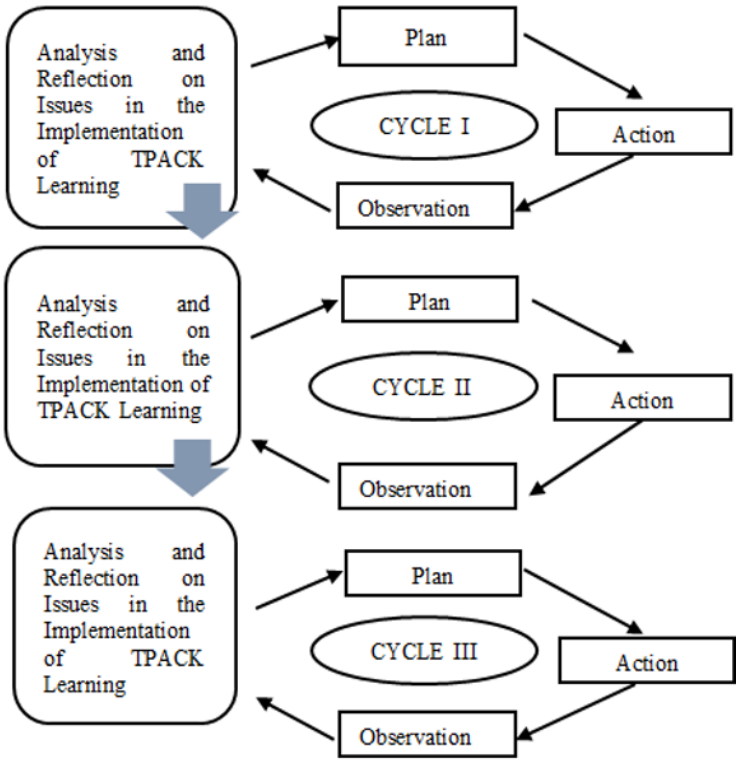

Fig 1. Flow of Implementation in John Eliot's Action Research Mode.

2.4 Data collection techniques

The data collection techniques used are as follows: Mathematical ability tests are conducted at the end of each cycle. The tests are structured in essay form based on the learning indicators in the Linear Programming course.

2.5 Data analysis technique

The data from the mathematical ability tests are analyzed descriptively and then divided into predicate achievements based on the Assessment Guidelines for predicates and the Student Grade Range applicable at IAIN Palopo. Here is the table of students' mathematical ability predicates.

Table 1. Mathematical Ability Predicates.

Score	Predicate
$85 \leq X \leq 100$	A
$75 \leq X < 85$	A-
$67 \leq X < 75$	B
$61 \leq X < 67$	B-
$55 \leq X < 61$	C
$45 \leq X < 55$	C-
$35 \leq X < 45$	D
$0 \leq X < 35$	E

3 Research results and discussion

The mathematical ability test at the end of each cycle. The test is structured in an essay format based on the learning indicators in the Linear Programming course. The success indicators in this research are The average mathematical ability of students must achieve at least a C predicate. The following is the presentation of data on the improvement of students' mathematical abilities in cycles I, II, and III, and Improvement Students' Mathematical Abilities.

3.1 Students' mathematical abilities in cycle I

In the implementation of the Technological Pedagogical Content Knowledge learning design as a support for the free learning campus curriculum, the results obtained in cycle I were as follows: an average of 18,18% of students achieved grades A and A-, 40,91% achieved grades B and B-, and 40,91% achieved grades C and C-.

Table 2. Students' mathematical abilities in cycle I

No.	Mathematical Ability Grade Predicate	Cycle 1	Total	%	Success Criteria
1	A	1	4	18,18	Not Yet Successful
2	A-	3			
3	B	5	9	40,91	
4	B-	4			
5	C	7	9	40,91	
6	C-	2			
7	D	0	0	0	
8	E	0			
Total		22	22	100	

3.2 Students' mathematical abilities in cycle II

In the implementation of the Technological Pedagogical Content Knowledge learning design as a support for the free learning campus curriculum, the results obtained in cycle I were as follows: an average of 54,55% of students achieved grades A and A-, 31,82 % achieved grades B and B-, and 13,64 % achieved grades C and C-.

Table 3 Students' mathematical abilities in cycle II

No.	Mathematical Ability Grade Predicate	Cycle 1I	Total	%	Success Criteria
1	A	5	12	54,55	Not Yet Successful
2	A-	7			
3	B	5	7	31,82	
4	B-	2			
5	C	3	3	13,64	
6	C-	0			
7	D	0	0	0	
8	E	0			
Total		22	22	100	

3.3 Students' mathematical abilities in cycle III

In the implementation of the Technological Pedagogical Content Knowledge learning design as a support for the free learning campus curriculum, the results obtained in cycle I were as follows: an average of 77, 27% of students achieved grades A and A-, and 22,73 % achieved grades B and B-.

Table 4. Students' mathematical abilities in cycle III

No.	Mathematical Ability Grade Predicate	Cycle 1II	Total	%	Success Criteria
1	A	8	17	77,27	Successful
2	A-	9			
3	B	4	5	22,73	
4	B-	1			
5	C	0	0	0	
6	C-	0			
7	D	0	0	0	
8	E	0			
Total		22	22	100	

3.4 Improvement students' mathematical abilities

In the implementation of the Technological Pedagogical Content Knowledge learning design as a support for the free learning campus curriculum, the results obtained were as follows:

In cycle I, an average of 18.18% of students achieved grades A and A-, 40.91% achieved grades B and B-, and 40.91% achieved grades C and C-. In cycle II, an average of 54.55% of students achieved grades A and A-, 31.82% achieved grades B and B-, and 13.64% achieved grades C and C-. As for cycle III, an average of 77.27% of students achieved grades A and A-, 22.73% achieved grades B and B-, and there were no students who achieved grades C and C-. This indicates a decrease in the number of students obtaining grades B, B-, C, and C- in cycle III and an increase in the number of students obtaining grades A and A-. So, it can be concluded that there has been an improvement in students' mathematical abilities after the implementation of Technological Pedagogical Content Knowledge learning in teaching.

3.5 Implementation of technological pedagogical content knowledge in efforts to improve mathematical abilities

The Ministry of Education and Culture (Kemendikbud), as the primary sector in national education playing a crucial role in achieving the quality of human resources in Indonesia, followed up by issuing various important policies, including the "Merdeka Belajar" (Freedom to Learn) program. Merdeka Belajar is one of the programs aimed at creating a pleasant and joyful learning environment in schools, for both students and lecturers. The background behind the launch of the Merdeka Belajar program lies in the complaints from parents about the existing national education system, including the varying minimum passing grades that students must achieve in each subject.

Smith and Ragan define instructional design as "a systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, learning activities, information resources, and learning evaluation." From this definition, Smith and Ragan emphasize that instructional design is a systematic and reflective process to translate principles of learning and instruction into a planning form used for learning materials, learning activities, learning resources, and learning evaluation.

The TPACK (Technological Pedagogical Content Knowledge) learning model integrates ICT (Information and Communication Technology) into classroom learning. This technology integration facilitates the students' learning process by employing appropriate teaching strategies and technology within the classroom. The TPACK model is effective in empowering educators to utilize technology in teaching, ultimately enhancing classroom learning effectiveness.

Based on the research conducted by researchers on third-semester students in the Mathematics Education Study Program at IAIN Palopo in the Academic Year 2022-2023, Class IIIA consisted of 22 students. Research findings include: In the implementation of technological pedagogical content knowledge to enhance mathematical abilities, results in Cycle I showed that 18.18% of students achieved grades A and A-, 40.91% achieved grades B and B-, and 40.91% achieved grades C and C-. In Cycle II, 54.55% of students achieved grades A and A-, 31.82% achieved grades B and B-, and 13.64% achieved grades C and C-. In Cycle III, 77.27% of students achieved grades A and A-, 22.73% achieved grades B and B-, and no students achieved grades C and C-. This indicates that in Cycle III, there was a decrease in the number of students receiving grades B, B-, C, and C-, and an increase in the number of students receiving grades A and A-.

Based on the research findings, it can be concluded that the implementation of technological pedagogical content knowledge to enhance mathematical abilities can improve students' mathematical connection abilities. This research aligns with Imamul Khaira et al.'s study titled "Implementation of TPACK-Based Learning Design as an Integration of Learning in the Society 5.0 Era to Improve the Learning Outcomes of Health Economics Courses," which states that in the Society 5.0 era, successful classroom learning

relies on the use of technology in learning activities. The results of this research were obtained from observations of lecturers implementing TPACK-based learning design, observations of student learning activities in TPACK-based learning, and student learning outcome test instruments. The results of this research indicate an improvement in student learning outcomes in the Health Economics course through the implementation of TPACK-based learning design.

4 Conclusion

Based on the research findings conducted by the researchers, several key findings have emerged: There was a notable improvement in students' mathematical connection abilities in the Implementation of technological pedagogical content knowledge in efforts to improve mathematical abilities. In Cycle III, 22.73% of students received grades B and B-, and there were no students who received grades C and C-. This indicates a decrease in the number of students receiving grades B, B-, C, and C- and an increase in the number of students receiving grades A and A- in Cycle III.

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