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ORIGINAL

Problem, realistic, technology in mathematics (protectim) learning model founded on blended learning

Problema, realista, tecnología en matemáticas (protectim) modelo de aprendizaje fundamentado en el aprendizaje combinado

Yarisda Ningsih[1], Lufri[2], I Made Arnawa[3], Dony Novaliendry[4], Rahmat Fadillah[5]

[1]Universitas Negeri Padang, Department of Primary School Teacher Education, Faculty of Education, Padang, Indonesia.
[2]Universitas Negeri Padang, Department of Biology, Faculty of Mathematics and Science, Padang, Indonesia.
[3]Universitas Andalas, Padang, Indonesia.
[4]Universitas Negeri Padang, Electronics Department, Faculty of Engineering, Padang, Indonesia.
[5]Universitas Negeri Padang, Department Technology and Vocational Education, Padang, Indonesia.

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Corresponding author: Dony Novaliendry

ABSTRACT

This research addresses the need for innovative learning models, specifically problem-based learning, to overcome challenges in primary teacher education. The study proposes the PROTECTIM learning model, a blended learning-based framework designed to enhance the pedagogical competencies of primary teacher education students. The main objective of this study is to develop a valid, practical and effective PROTECTIM learning model that supports the pedagogical competencies of prospective primary school teachers. The study employs a project-based research methodology, evaluating the suitability of the model in terms of content, structure and language. The study uses sample materials including textbooks, teacher workbooks and student workbooks as references. The research participants are PGSD students who have completed elementary-level geometry and measurement courses. The PROTECTIM model incorporates a structured syntax comprising the following steps: problem clarification, problem statement, understanding, student experiences, presentation, reflection, and evaluation. The results indicate that the PROTECTIM model developed meets the criteria for theoretical validity in terms of content, graphics and language. In addition, it meets the practical criteria, demonstrating ease of use, usefulness for learning, and attractiveness. In particular, the PROTECTIM model, based on the principles of blended learning, has proven to be an effective tool for improving the pedagogical competencies of PGSD students, thus making a substantial contribution to the field of primary teacher education.

Keywords: Learning Model; PROTECTIM; Blended Learning.

RESUMEN

Esta investigación aborda la necesidad de modelos de aprendizaje innovadores, en concreto el aprendizaje basado en problemas, para superar los retos en la formación de maestros de primaria. El estudio propone el modelo de aprendizaje PROTECTIM, un marco basado en el aprendizaje combinado diseñado para mejorar las competencias pedagógicas de los estudiantes de Magisterio de Primaria. El objetivo principal de este estudio es desarrollar un modelo de aprendizaje PROTECTIM válido, práctico y eficaz que apoye las competencias pedagógicas de los futuros maestros de primaria. El estudio emplea una metodología de investigación basada en proyectos, evaluando la idoneidad del modelo en términos de contenido, estructura y lenguaje. El estudio utiliza como referencias materiales de muestra, incluidos libros de texto, cuadernos de trabajo del profesor

y cuadernos de trabajo del alumno. Los participantes en la investigación son alumnos del PGSD que han completado cursos de geometría y medición de nivel elemental. El modelo PROTECTIM incorpora una sintaxis estructurada que comprende los siguientes pasos: clarificación del problema, planteamiento del problema, comprensión, experiencias de los alumnos, presentación, reflexión y evaluación. Los resultados indican que el modelo PROTECTIM desarrollado cumple los criterios de validez teórica en cuanto a contenido, gráficos y lenguaje. Además, cumple los criterios prácticos, demostrando facilidad de uso, utilidad para el aprendizaje y atractivo. En particular, el modelo PROTECTIM, basado en los principios del aprendizaje combinado, ha resultado ser un instrumento eficaz para mejorar las competencias pedagógicas de los estudiantes de PGSD, contribuyendo así de forma sustancial al ámbito de la formación del profesorado de primaria.

Palabras clave: Modelo de Aprendizaje; PROTECTIM; Aprendizaje Combinado.

INTRODUCTION

Education is vital for developing a generation capable of adapting to and competing in a progressively dynamic global environment. Basic mathematics education in Indonesia is essential for developing critical thinking and problem-solving skills required for the demands of the Industrial Revolution 4.0.[1] The Ministry of Education and Culture has commenced initiatives to enhance educational quality through new learning methodologies that actively and interactively include students in the learning process.[2]

The blended learning paradigm, which integrates in-person instruction with adaptable online learning, is a pedagogical strategy that supports this objective and enhances students' educational experiences. Recent research indicate that blended learning enhances students' cognitive abilities by offering increased access to educational resources and flexibility in time management.[3]

Education is essential in this context. The Ministry of Education has sought to improve the relevance and quality of character education by developing exemplary educational programs for each educational pathway, level, and unit type.[4,5,6] Mathematics is a discipline that necessitates advanced cognitive skills. Mathematics is an essential ability that can enhance kids' potential. This discipline is imparted at all educational tiers, with school mathematics being instructed from primary education to higher education.[7,8,9]

Mathematics is essential for cultivating critical thinking and analytical skills; nonetheless, students often face significant difficulties in understanding mathematical concepts. These challenges stem partly from traditional pedagogical methods that prioritize rote memorization and procedural learning over fostering a deep understanding of topics. Consequently, students may find it challenging to relate mathematical theories to practical applications, fostering the view of mathematics as an abstract and arduous discipline. This disparity between theory and practice underscores the necessity for novel instructional strategies that render mathematics more approachable and pertinent to students.[10]

The Industrial Revolution 4.0 has heightened the demand for equipping students with adaptable and pragmatic abilities. The rapid advancement of technology has increased the demand for workers with strong analytical and problem-solving abilities.[11] Mathematics constitutes a foundational base for scientific and technological fields, further enhancing this necessity. Consequently, educational systems must adapt to equip students for the intricate difficulties of the future workforce by including methodologies that prioritize critical thinking, teamwork, and technology-enhanced learning.[1,3]

Mathematics is a discipline that positively helps to the advancement of science and technology.[12,13,14] [10] asserted, "Mathematics is the key to opportunity," and characterized mathematics as "the science of patterns and order," indicating that it pertains to patterns, regularities, and hierarchies. Nonetheless, mathematics remains seen as challenging to master. This issue may stem from complex content, inappropriate pedagogical methods, inadequate learning theories, or a lack of classroom resources.[15,16,17] [18] asserts that a contributing element to students' inadequate or partial understanding of mathematical ideas is the instructional methods utilized by instructors. The traditional teaching method regards pupils solely as passive recipients in the educational process.[19]

In response to these requirements, educational researchers have examined various pedagogical frameworks that prioritize student-centered learning and practical problem-solving. Realistic Mathematics Education (RME) is recognized as an effective approach for mathematics instruction. RME fosters student involvement with mathematical concepts via practical, real-world contexts, allowing them to acknowledge the importance of mathematics in daily life. RME enhances students' intuitive understanding of mathematical principles by anchoring abstract concepts in concrete situations, which may improve knowledge retention and application.[8]

In conjunction with RME, Problem-Based Learning (PBL) has arisen as an effective approach for fostering critical thinking skills. In PBL, students face complex, open-ended issues that require the analysis, assessment, and synthesis of information. This strategy aligns with the goals of RME by enabling students to tackle genuine challenges, therefore linking classroom learning with real-world application. The integration of RME and PBL

establishes a comprehensive framework for mathematics education that fosters both conceptual comprehension and the enhancement of problem-solving abilities.[12,20]

Various 21st-century methodologies, including constructivism, Realistic Mathematics Education (RME), Problem-Based Learning (PBL), and Project-Based Learning (PJBL), have been suggested to enhance the educational process.[2,21] RME, specifically designed for mathematics education, has the potential to transform the learning experience (20). The RME technique, first introduced and refined by the Freudenthal Institute in the Netherlands in 1971, has been adopted and adapted by other industrialized countries, including England, the United States, Spain, Germany, Denmark, Japan, and Malaysia.[22,23]

In light of the prevailing educational issues, there exists an imperative to innovate within the educational sphere, especially via problem-oriented learning.[11,24,25] Education ought to furnish students with problem-solving abilities. Meeting these needs necessitates a learning strategy that can assist students in enhancing their pedagogical competencies as prospective primary school educators.[1,3] The author deems it essential to implement these research efforts through the development of the PROTECTIM paradigm, which is grounded in blended learning. This paradigm enhances blended learning through the integration of several methodologies.

The PROTECTIM model (Problem, Realistic, Technology in Math) aims to improve the pedagogical skills of prospective primary school teachers in instructing geometry and measuring topics. PROTECTIM integrates Project-Based Learning (PBL) with Realistic Mathematics Education (RME), highlighting technology-assisted, authentic problem-solving. This paradigm caters to students' requirements to comprehend mathematics as a practical and pertinent field in everyday life.[22,26,27]

Research demonstrates that the RME technique significantly aids students in cultivating a profound comprehension of mathematical topics by utilizing real-life scenarios as a foundational learning tool.[8,20] PBL establishes a robust framework for developing critical thinking abilities via organized challenges and problem-solving tasks.[8,20] Thus, PROTECTIM is anticipated to enhance students' pedagogical and cognitive abilities comprehensively through a flexible and contextual methodology.

The research underpinning the syntactic framework of the PROTECTIM learning model was carried out by [22,26,27]. The PROTECTIM learning paradigm, as outlined by [26], has the following stages: 1) information search, 2) discovery, comprehension, and engagement with ideas, 3) information interpretation, 4) idea communication, 5) information construction, and 6) conclusion formulation from data. [26] delineates the steps as follows: 1) setting, 2) teacher role, 3) student experience, and 4) mixing. According to [27], the stages encompass class setup, preparation of learning materials, student organization, provision of introductory materials, station learning, presentations, and reflection and evaluation.[22,26,27,28]

The conceptual foundation of the PROTECTIM Learning Model's stages (syntax) is informed by pertinent research on the blended learning model. The study that guided the formulation of the PROTECTIM model's syntax was carried out by [22,26,27].

a. Entails the pursuit of information both online and offline, emphasizing relevance, validity, content authenticity, and academic rigor; discovering, comprehending, and challenging concepts; analyzing data from diverse sources; articulating ideas through various mediums; and synthesizing knowledge via assimilation and accommodation processes, alongside deriving conclusions from acquired information.[26]

b. Entails organizing classrooms into stations, facilitating student movement from one station to another. The instructor arranges rotation schedules, with each station utilizing a distinct method to achieve the same educational objectives. Students engage independently, collaboratively, or with instructors, contingent upon the station. Online stations may encompass tasks such as surveys, writing assignments, auditory storytelling, or responding to inquiries.[22]

c. Entails establishing courses, creating educational resources, gathering students, supplying introduction materials, implementing station-based learning, delivering presentations, and conducting reflection and assessment.[27]

The PROTECTIM learning model, grounded in the principles of blended learning, has been meticulously designed to address critical needs that have been identified through a comprehensive questionnaire administered to both lecturers and students. This model comprises two manuals: the Lecturer Work Manual (BPKD) and the Student Work Manual (PKPM). The objective of these manuals is to enhance educational outcomes and professional competencies. The incorporation of technology into mathematics instruction is a pivotal aspect of the PROTECTIM approach, as it equips future educators with the essential skills to address evolving educational challenges.[11] The implementation of the PROTECTIM approach in Primary School Teacher Education Programs has yielded improvements in students' cognitive abilities and mathematical problem-solving skills.

The PROTECTIM (Problem, Realistic, Technology in Math) paradigm was created to integrate the advantages of Realistic Mathematics Education (RME) and Problem-Based Learning (PBL) into a blended learning environment. The PROTECTIM concept combines in-person instruction with online learning, creating a versatile educational environment that caters to various learning styles and speeds. This hybrid method utilizes technology to grant access to diverse educational resources, facilitating self-directed learning for students beyond the classroom.

This methodology enhances students' comprehension of mathematics while simultaneously acquainting them with digital technologies, thereby equipping them for the progressively digital environment of the contemporary workforce.[22,26]

Furthermore, the syntax of the PROTECTIM model is meticulously organized to provide a sequential learning process for pupils. Every phase—from Problem Statement to Evaluation—fulfills a distinct role in enhancing students' cognitive and pedagogical competencies. The Problem Statement phase presents students with real-world situations necessitating mathematical reasoning, whereas the Understanding and Experience stages promote collaborative investigation of these situations through theoretical concepts and digital technologies. This sequential method guarantees that students acquire mathematical concepts and comprehend their practical applications, so augmenting their knowledge and confidence in mathematics.[29]

Initial applications of the PROTECTIM concept among elementary school teacher candidates have demonstrated encouraging outcomes. Students engaged in PROTECTIM-based learning sessions exhibited greater problem-solving abilities and an improved capacity to relate mathematical ideas to real-world scenarios. These results demonstrate that the model is successful in enhancing cognitive skills and cultivating a favorable disposition towards maths. This study aims to create a transformative impact by equipping prospective educators with the PROTECTIM paradigm, thereby empowering them to implement innovative pedagogical techniques effectively in their classrooms. By fostering these advanced instructional practices, the study seeks to enhance mathematics teaching on a broader scale, ultimately contributing to improved learning outcomes and addressing future educational challenges.[28]

METHOD

This study used a developmental research design to create, delineate, and assess instructional goods. [21] characterize developmental research as a methodical process for the design and creation of educational products, including programs, models, instructional materials, teaching strategies, and other educational resources, aimed at addressing intricate issues.[17,22,30] The principal outcome of this project is the PROTECTIM learning model, a blended learning methodology intended to be valid, practical, and beneficial in improving students' performance and creativity. Product testing was performed to ascertain any deficiencies, constraints, appropriateness, feasibility, and efficacy of the model. The testing methods encompassed individual assessments, restricted group evaluations, and extensive group testing via expert analyses, micro-assessments, and classroom exercises.

The PROTECTIM (Problem, Realistic, Technology in Math) learning model integrates Problem-Based Learning (PBL) and Realistic Mathematics Education (RME) within a blended learning framework that encompasses both in-person and online educational settings. The methodology aims to improve mathematical understanding and teaching skills in prospective elementary school educators. This hybrid model offers a versatile and engaging method for learning, meeting the demand for novel educational solutions in teacher training programs. This study involved third-semester students from the Primary School Teacher Education Department at Universitas Negeri Padang (PGSD FIP UNP), particularly those taking geometry and measurement courses. A total of 26 students were chosen via random sampling to provide a representative diversity of talents, and they offered insights regarding the model's practicality and efficacy.

The development approach for the PROTECTIM model comprised four primary phases, taken from the model development frameworks suggested by [29,31]. The initial phase, Needs Analysis, entailed collecting data through faculty interviews, student questionnaires, and an examination of curriculum requirements to pinpoint deficiencies in current teaching methods and underscore the necessity for a blended learning paradigm centered on authentic problem-solving. The second phase, Prototype Design, entailed developing a prototype informed by the needs analysis, encompassing stages such as problem clarity, problem statement, comprehension, student experiences, presentation, reflection, and assessment. This syntax was modified based on the literature of PBL and RME to guarantee conformity with blended learning principles.[22,26,27]

Subsequent to the design phase, the Prototype Evaluation step examined the initial prototype's validity and practicality via expert assessments and individual testing. Mathematics education and instructional design experts evaluated the model's content, structure, and functioning to confirm theoretical validity and pedagogical coherence. Subsequent testing with a specific cohort of students yielded comments on usability, relevance, and comprehensibility, resulting in essential modifications and enhancements to optimize the model.

The study used both quantitative and qualitative methods to evaluate the PROTECTIM model's validity, practicality, and effectiveness. Experts assessed content, structure, and graphics using Likert-scale validation forms. Observations and practicality forms measured student interaction and compliance with the model's syntax. Pre- and post-tests analyzed via ANCOVA examined the model's impact on mathematical understanding. Surveys and interviews provided qualitative feedback on strengths and areas for improvement.[25]

RESULTS

The results of this study demonstrate that the PROTECTIM learning model, which integrates Problem-Based

Learning (PBL) and Realistic Mathematics Education (RME) within a blended learning framework, effectively enhances the pedagogical skills of PGSD students. Data analysis revealed that the model meets theoretical validity criteria in terms of content, graphics, and language, as validated by experts. The following section delineates the grand theory that constitutes the state of the art of this PROTECTIM syntax.

Table 1. State of Art

Ramsay (2001)	Darmayasa and Aras (2019)	Widyaningsih et al. (2019)	*PROTECTIM* based on *Blended Learning*
Information search	Set-Up	Setting up a classroom and preparing learning tools	Problem statement
Discover, understand and confront ideas	Teacher Role	Organizing students	Understanding
Interpreting information	Students experience	Providing introductory materials	Students experience
Communicating ideas/ideas	The Blend	Study at station	Presentation
Withdrawal of Information		Rotate	Reflection
		Presentation	Evaluation
		Reflection & evaluation	

This model is anticipated to enhance a teacher's pedagogical skills. Consequently, the Blended Learning-based PROTECTIM model was formulated in accordance with the blended learning model syntax suggested by many experts and sources as outlined in table 1. The conceptual foundation of the stages (syntax) of the PROTECTIM learning model pertains to several pertinent research findings. The PROTECTIM approach is predicated on Blended Learning, utilizing the subsequent syntax:

Table 2. The Conceptual Foundation of the PROTECTIM Syntax

Syntax model *PROTECTIM*	Activity description	
	Lecturer	Student
Problem statement (Offline & Online)	1. Lecturers direct students to topic discussions 2. Lecturers ask essential questions to students	1. Students observe the Lecturer's explanation 2. Students ask and answer questions with lecturers 3. Students agree on one topic in elementary school Geometry and Measurement learning.
Understanding (Offline)	1. Lecturers facilitate Teaching Materials sent at e-learning. 2. The lecturer asked students to form a group.	1. Students understand the topic of the activity. 2. Students understand and access Teaching Materials in e-learning. 3. Students form groups.
Students experience (Offline & Online)	1. Lecturers facilitate students for group work. 2. Lecturers facilitate students to use IT devices in accelerating assignments.	1. Students read/search for various sources from elementary Geometry and Measurement learning. 2. Students in the group searched for and completed the assignment materials (e-modules) given. 3. Students create/complete e-module assignments given by the Lecturer.
Presentation (Offline)	1. Lecturers facilitate the presentation of group assignments done by students. 2. The lecturer observed the presentation of the assignment presented by the students.	1. Students perform the results of group assignments (e-module) 2. Students from other groups gave responses to the presenting group regarding the e-modules they displayed.
Reflection (Offline)	1. Lecturers guide students to draw conclusions related to the learning that has been carried out. 2. Lecturers assess and reward groups that succeed in coming up with conclusions in learning that has been carried out.	1. Students ask and answer questions about the activities that have been carried out. 2. Students point out weaknesses and advantages in learning activities. 3. Students express their opinions about solutions of the group's own weaknesses
Evaluation (online)	1. Lecturers give assignments to students individually. 2. Lecturers assess individual assignments made by students.	1. Students do assignments given by the Lecturer individually. 2. Students collect assignments given by the Lecturer individually.

This serves as a framework for educators employing the learning model and for pupils enrolled in elementary school Geometry and Measurement courses, with syntax, also referred to as phases, delineating the sequence

of activities (29). The PROTECTIM Learning Model, founded on Blended Learning, comprises six distinct learning phases, outlined as follows:

1) Problem Statement (Offline & Online)
2) Understanding (Offline)
3) Student Experience (Offline & Online)
4) Presentation (Offline)
5) Reflection (Offline)
6) Evaluation (Online)

The creation of a PBL model, namely the PROTECTIM model, founded on blended learning, incorporates findings from the preliminary study, prototype phase, formative assessment, and evaluation phase. Subsequently, we examine the research outcomes and constraints of the study. The syntax of the Problem Realistic, Technology In Math (PROTECTIM) Learning Model, grounded in Blended Learning, is articulated into educational schemes and scenarios that emphasize the active participation of both students and lecturers in each learning phase, as illustrated in figure 1 below:

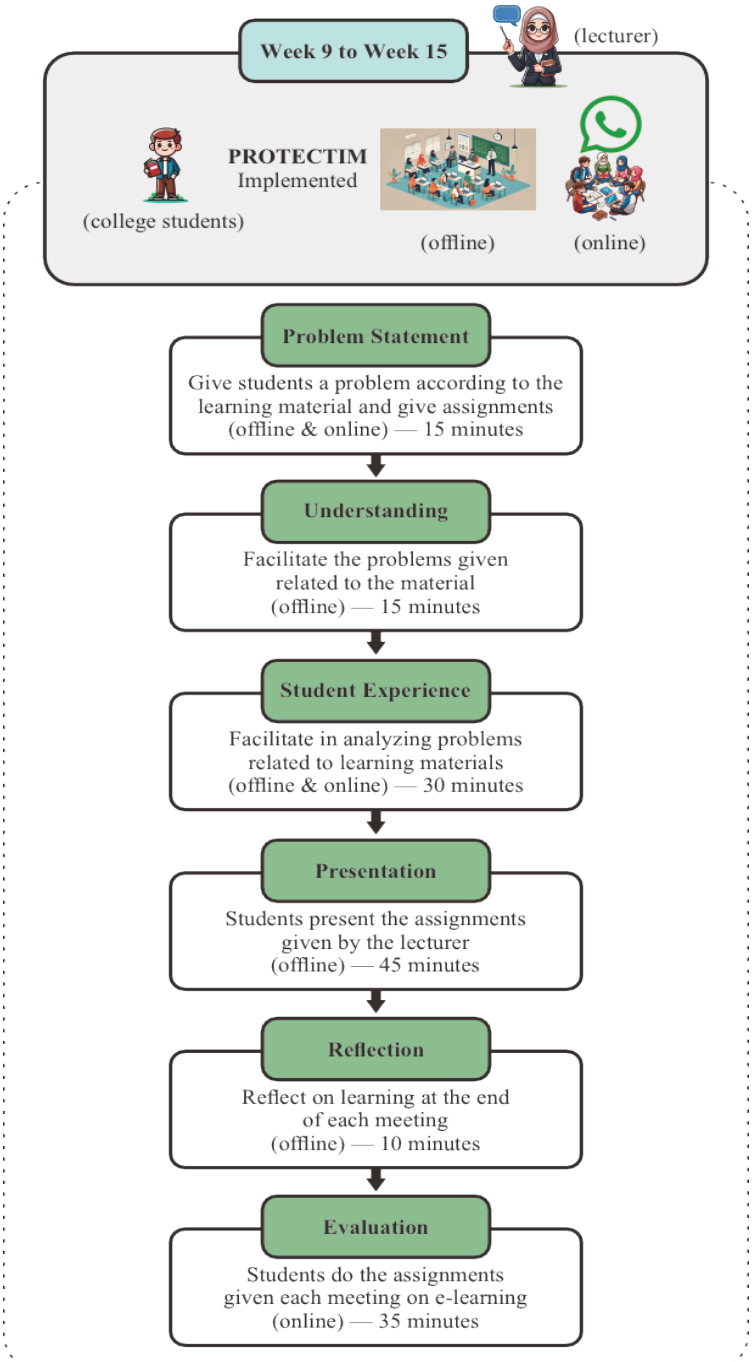

Figure 1. Illustrates the application of the PROTECTIM learning model during a single meeting

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This analysis and contextual activity utilizes data from three sources: (1) faculty interviews, (2) student needs survey data, and (3) curriculum analysis data. The researcher conducted interviews with the teaching staff concerning the essential elements to be incorporated into the foundational concept of the PROTECTIM model, which is predicated on blended learning. The findings indicated that effective learning necessitates a model capable of conveying theoretical concepts alongside demonstrable real-world issues. A questionnaire assessing student needs and characteristics was administered to 26 students enrolled in a two-semester elementary school geometry and measurement course.

The outcomes of the RPS research of the elementary school geometry and measurement course may be attributed to the comprehensive implementation of various elements of the RPS design within the PROTECTIM learning model, which is predicated on blended learning, alongside the necessity for additional components. The findings of the SAP MK Geometry and SD Measurement study can be elucidated by the presence of multiple facets within the SAP design of the PROTECTIM learning model that have been thoroughly executed, while one facet requires further development.

The literature study revealed a novel aspect in the syntax of the Blended Learning-based PROTECTIM learning model that is absent in the syntax of the PBL model. This research product is grounded in theories derived from research findings.[22,26,27] These ideas are extensively examined to identify the optimal model, highlighting the innovation and superiority of the PROTECTIM learning paradigm grounded in blended learning. Following the findings of the preliminary research, a prototype was conceived and constructed, comprising three phases: the design phase, form evaluation, and prototype revision. The outcomes of the design and development prototype are elucidated as follows.

Table 3. Analysis of Covariance for Comprehensive Designs of Mathematical Comprehension Proficiency

Test of Between - Subject Effects						
Dependent Variable : Mathematical Understanding Score						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	9826,184a	2	3858,092	34,042	,000	,437
Intercept	795,953	1	772,952	4,547	,019	,073
Initial Value	1892,475	1	1865,435	12,843	,000	,160
Model	8941,461	1	7411,461	57,631	,000	,401
Error	7582,937	52	135,840			
Total	19212,826	57				
Corrected Total	23470,121	52				

Note: a. R Squared = ,534 (Adjust R Squared =,519)

The computed F for mathematical comprehension ability is 57,631, with a significance level of 0,000. Utilizing degrees of freedom (db) equal to 1 and 63 (66-2-1), the F table value is 3,99 at the 5 % significance level. Due to the nature of this research employing a one-tailed test, specifically a left-tailed test, and referencing a F table value of 3,99, the computed F value of 57,631 resides inside the acceptance region of the null hypothesis (Ho). Consequently, it is determined that the implementation of the PROTECTIM Learning Model, grounded on Blended Learning, is superior to the educational outcomes of students who do not utilize the PROTECTIM Learning Model based on Blended Learning.

The implementation of the PROTECTIM model demonstrates substantial enhancements in students' arithmetic comprehension and problem-solving abilities. Data analysis from students enrolled in geometry and measurement courses indicated an enhancement in learning outcomes, as demonstrated by assessment results and favorable student feedback. Blended learning facilitated the flexible delivery of materials both online and offline, enhancing student engagement and motivation to comprehend geometry topics more profoundly.

Quantitative results revealed a substantial enhancement in students' comprehension of mathematical topics, evidenced by an F-value of 57,631 ($p < 0,001$), underscoring a noteworthy disparity in learning outcomes between students utilizing PROTECTIM and those in the control group who did not employ this model. These findings corroborate prior studies indicating that blended learning and RME methodologies substantially enhance learning outcomes in mathematics education.

DISCUSSION

The topic of this research centers on achieving the aims of producing accurate, practical, and effective products. This outlines the discussion based on the researcher's results at each phase of the investigation.

1. Conclusions of the previous research results

The findings from the analysis of user needs regarding the response principle components of the PROTECTIM model, which is based on blended learning, can be succinctly summarized as follows: (1) lecturers should assume roles as mentors, peers, and motivators of learning; (2) there must be a commitment to the completion of the study project; (3) lecturers should provide answers and feedback during the learning process; (4) educators must offer comprehensive explanations regarding the utilization of technology. The notion of responsibility aims to foster learning motivation among students during their educational process.

This study examines the effect of the PROTECTIM Learning Model, a blended learning methodology, on students' mathematics understanding skills through Analysis of Covariance (ANCOVA). Essential statistical metrics, such as Sum of Squares, F-value, Significance (Sig.), and Partial Eta Squared, offer insights into the model's efficacy. The analysis illustrates that the PROTECTIM model, which integrates Problem-Based Learning (PBL) and Realistic Mathematics Education (RME), can markedly improve the educational achievements of prospective elementary school teachers through the utilization of both online and in-person instruction.

2. Conclusions from the results of the design and development prototype

Observations were conducted during the design and development process on the validity test results of the PROTECTIM model support system, which is based on blended learning, practitioner evaluations, and practicality assessments. The validity assessment of the PROTECTIM learning model book, grounded in blended learning, typically meets valid criteria. The model book attained its maximum validity test achievement from the standpoint of the social system.

The ANCOVA findings demonstrate that the PROTECTIM model accounts for a substantial percentage of the variance in students' mathematical comprehension scores. The Corrected Model has an F-value of 34,042 and a Partial Eta Squared of 0,437, indicating that about 43,7 % of the variance is ascribed to the model's components, including initial scores and the instructional methodology. The Learning Model component exhibits an F-value of 57,631 and a Partial Eta Squared of 0,401, demonstrating high significance ($p < 0,001$), signifying that the PROTECTIM model accounts for 40,1 % of the variation, irrespective of baseline comprehension levels.

The PROTECTIM paradigm was developed to enhance mathematical understanding by authentic problem-solving and technological incorporation. An R-Squared value of 0,534 indicates that 53,4 % of the variance in mathematical understanding scores is accounted for by the model, demonstrating its robustness and practical significance. The substantial effect size, as evidenced by the Partial Eta Squared value, demonstrates that the PROTECTIM model considerably influences learning outcomes, providing a more efficacious alternative to conventional teaching approaches.

3. Conclusions from the results of the evaluation phase

This paper presents the evaluation phase results, which assess the efficacy of the PROTECTIM learning paradigm grounded in blended learning. The initial indicator of the model's efficacy is the attainment of pedagogical abilities by students, resulting from the instructional impact of the PROTECTIM learning model, which utilizes blended learning.

The findings indicate that blended learning models such as PROTECTIM, which integrate realistic and technology-enhanced problem-solving, can boost students' comprehension of mathematical topics. The statistically substantial enhancements in comprehension highlight the importance of these models in educational practice. Educators should contemplate implementing such strategies in mathematics and other disciplines where practical understanding is crucial, as this blended learning model promotes cognitive development and engagement.

This study offers substantial evidence for the efficacy of the PROTECTIM paradigm; however, additional research might investigate its long-term effects and juxtapose it with other blended learning models across other student demographics. A qualitative review of student responses may provide insights into particular model components that improve engagement and understanding. The PROTECTIM Learning Model demonstrates significant promise for revolutionizing mathematics education through the integration of practical problem-solving and digital resources.

The implementation of the PROTECTIM model in a blended learning context tackles pedagogical issues in mathematics teaching. The incorporation of RME in this approach promotes students' comprehension of mathematical concepts through real-world scenarios, hence facilitating the connection between theoretical knowledge and practical applications in daily life.[7,8] This method not only renders the learning experience more captivating but also augments pupils' capacities to autonomously resolve intricate issues.

The PBL component in PROTECTIM enhances students' critical and analytical thinking abilities. This technique trains students to examine problems, devise solutions, and systematically interpret data, rather than merely memorizing formulas or procedures. Research by [12] indicates that PBL efficiently promotes active student participation and improves problem-solving abilities in mathematics.[12]

In addition to enhancing cognitive dimensions, the PROTECTIM concept offers advantages in educational and motivational assistance for students. In this model, the lecturer's function transitions from instructor to facilitator, emphasizing the guidance and cultivation of students' independent learning skills.[4] This method is crucial for developing independent and adaptive learners, a necessity for 21st-century education.

The findings align with the research conducted by [2], which underscores the significance of blended learning in enhancing student motivation and promoting a more profound comprehension of the subject matter. In this context, PROTECTIM offers substantial contributions to innovation in mathematics education by prioritizing real-world applications and problem-based learning.

The PROTECTIM model provides a robust framework for educators to efficiently teach mathematics using a blended learning method. This strategy enhances mathematics comprehension while fostering the advancement of professional and pedagogical competencies in prospective educators. Consequently, PROTECTIM might work as a benchmark for formulating educational models in various domains that necessitate the amalgamation of theory and practice via adaptive and innovative pedagogical approaches.

CONCLUSION

This study successfully developed the PROTECTIM learning model, which integrates Problem-Based Learning (PBL) and Realistic Mathematics Education (RME) into a blended learning framework. The model's validity has been substantiated through expert evaluation, with its content, structure, and graphical presentation receiving commendation. Practicality tests demonstrated that the model is easy to use, engaging, and effective in facilitating student interaction and adherence to the learning syntax. Furthermore, the analysis of pre- and post-test results through ANCOVA substantiated the efficacy of the model in enhancing the pedagogical competencies of PGSD students, particularly in the domains of geometry and measurement. These findings underscore the considerable impact of the PROTECTIM model in addressing contemporary challenges in primary school teacher education.

The model employs a systematic approach to cultivating future educators' problem-solving and critical thinking abilities, while integrating technological tools into mathematics instruction. The alignment of the model with contemporary educational imperatives positions it to address the evolving challenges inherent in teaching and learning processes. This research underscores the practical application of the PROTECTIM model and contributes to the broader discourse on innovative, technology-driven instructional models in education. Consequently, the PROTECTIM model is regarded as a transformative instrument for enhancing the quality of mathematics education and equipping future teachers with the competencies necessary for professional success.

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AUTHORSHIP CONTRIBUTION

Conceptualization: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Data curation: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Formal analysis: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Research: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Methodology: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Project management: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Resources: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Software: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Supervision: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Validation: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Visualization: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Writing – original draft: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.
Writing – revision and editing: Yarisda Ningsih,_Lufri, I Made Arnawa, Dony Novaliendry, Rahmat Fadillah.