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Development of a Learning Model Combining Learning Environment and Project-based Learning (LE-PROBALE Model) through Nila's Edumath Interactive Mobile Learning

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Abstract:

Introduction: This study focuses on the development, validation, and implementation of the LE-Probale learning model, which integrates technology-based scaffolding to foster mathematical literacy among junior high school students. The model is designed to enhance students' ability to understand and apply mathematical concepts by utilizing "Nila's Edumath Interactive Mobile Learning," a digital tool that supports interactive learning. The research follows a modified version of the Plomp model (1997) for educational development, involving five key phases: initial investigation, design, realization, testing and evaluation, and implementation. The initial investigation phase identified a gap in students' mathematical literacy and the need for innovative teaching models.

Objectives: The design phase focused on formulating the syntax, social systems, reaction principles, and support systems of the LE-Probale model.

Methods: The realization phase involved developing the teaching materials, digital tools, and assessment instruments. The model was validated by expert reviewers and tested through field trials in a junior high school, with teachers and students actively participating.

Results: The results of the field trials demonstrated that the LE-Probale learning model is both practical and effective. Students showed significant improvement in mathematical literacy, with the interactive scaffolding approach helping them construct and integrate mathematical concepts more efficiently. Teachers also reported positive feedback regarding the usability of the model in their classrooms.

Conclusions: The study concludes that the LE-Probale learning model, with its integration of technology-based scaffolding, offers a valuable approach to enhancing mathematical literacy. The model can be adapted across various mathematical topics and is ready for broader implementation in junior high schools.

Keywords: LE-Probale model, mathematical literacy, Nila's Edumath Interactive Mobile Learning, educational technology.

1. Introduction

The need to develop a learning model that integrates a conducive learning environment with Project-Based Learning (PBL) is becoming increasingly urgent due to several factors: (1) 21st-Century Skill Development: In today's education landscape, the emphasis is on cultivating 21st-century skills such as critical thinking, problem-solving, collaboration, and creativity. PBL has been shown to foster these skills by providing students with real-world problems to solve and opportunities to work in teams, which mirrors modern workplace environments. Learning environments that are supportive, engaging, and equipped with appropriate technological tools further enhance these skills by enabling a space where students feel motivated and are provided with the resources necessary for deeper inquiry and exploration. (2) Bridging Theory and Practice: One of the main challenges in education is bridging the gap between theoretical knowledge and practical application. PBL, when combined with a well-structured learning environment, helps students to contextualize theoretical concepts and apply them to real-world scenarios, enhancing their understanding and retention of knowledge.

Lu Zhang et al. (2023) conducted a meta-analysis on the impact of project-based learning, demonstrating that PBL significantly improves students' learning outcomes, including academic achievement, affective attitudes, and higher-order thinking skills. The study highlights that PBL is more effective when used in small group settings and over an extended period (9-18 weeks), particularly in engineering and technology subjects, and is better suited for practical classes rather than theoretical ones. Research on Computational Thinking and PBL (2023) explored the integration of computational thinking with PBL, showing that PBL enhances students' problem-solving abilities, creativity, and collaboration among students. The study emphasizes the need for more research on how PBL impacts different dimensions of computational thinking, especially at various educational levels.

Carrabba & Farmer (2023) investigated the effects of project-based learning on student motivation and social skills development. Their research suggests that PBL promotes collaboration, enhances group interactions, and helps develop interpersonal skills. The study also observed improvements in students' intrinsic motivation and engagement due to the autonomy and relevance provided by PBL environments. In today's educational landscape, there is an increasing emphasis on fostering students' mathematical literacy, a crucial skill set that enables learners to apply mathematical concepts in real-world situations. However, research and observations indicate that many junior high school students struggle with mathematical literacy, often finding it difficult to connect mathematical theories with practical applications. To address this issue, there is a need for innovative teaching approaches that not only engage students but also make learning mathematics more relevant and accessible. According to Charman (as quoted in Arifin & Abduh, 2021), the project-based learning model combines face-to-face education with online materials such as text, photos, diagrams, sound, and videos accessed by teachers and students via the Internet. These findings support Bathe and Bruke (2017) and Stein and Graham (2014) that the model combines online and face-to-face teaching, making it effective, efficient, and flexible to meet learner needs. The LE-Probale model is a teaching system that combines face-to-face technology-mediated teaching (Ubaidah, N., et al., 2024).

The LE-Probale model is the author's attempt to implement a learning environment with project-based learning so that they are intertwined with each other synergy and collaboration between educators and students to enhance the learning experience of students from the surrounding environment through the products they produce (Ubaidah, N., et al., 2024). The LE-Probale model traces to differentiated learning, which puts forward important indicators, namely: (1) Differentiation of content, which takes into account students' learning needs: learning readiness, interest aspects, and learning profile aspects; (2) Differentiation of the process, preparing various teaching and learning activities: in groups or independently; (3) Product differentiation, which relates to the products that students will produce: writing, test results, student work, performances, presentations, speeches, recordings, and keep on improving through. According to Sutopo (as quoted in Aslamiyah et al., 2019), a project-based learning model improves the quality and quantity of human interactions in the classroom. It combines good technology and interaction, and generates social support, constructive feedback, and learning experiences. Furthermore, this approach can be implemented effectively and successfully if educators and students collaborate to achieve the learning objectives (Saputri et al., 2021). Component learning completes each other to achive objective system learning to create an environment that is conducive for a student to maximize potential (Ramadania & Aswadi, 2020).

Approach to the Study

The research was conducted before the LE-Probale model through scaffolding based on technology from Nila’s Edumath Interactive Mobile Learning, which can help overcome the problem of a learning environment that cannot accommodate student characteristics that are different in an adequate manner (Hapizah, 2015; Hendrik et al., 2021; Kharisna et al., 2023 Sutianah et al., 2022; Ubaidah, N., et al., 2024). Students have a lot more flexibility in learning about them by participating in a learning mixture. This strategy pushes them to practice self-control and increases their ability to study. The LE-Probale model, through scaffolding based on technology from Nila’s Edumath Interactive Mobile Learning, allows students to accept explanation material from the teacher using Nila’s Edumath Interactive Mobile Learning facility, which can be accessed anywhere and anytime using an Android smartphone (Ubaidah, N., et al., 2024). The learning process does not directly show superior quality in terms of motivation, interest, and student learning outcomes (Usman, 2019). Hence, this strategy can become an alternative that is suitable and effective for the process of study and teaching. In line with this, previous research has found that quality education can be improved through learning processes and thinking exercises using an appropriate model. (Diana et al., 2019; Hapizah, 2015; Mask et al., 2020; Suastika, 2017).

The LE-Probale model, through scaffolding based on technology from Nila’s Edumath Interactive Mobile Learning, this aim was to enhance the mathematical literacy of students, which is very important in learning mathematics. According to Ojose (2011), and Stacey and Turner (2015), literacy related to mathematics involves an understanding of geometric ideas that should be owned by every student to enhance his creativity. This thing should be developed through school-based mathematicals learning. Furthermore, abstract mathematical objects and materials are difficult to identify and understand, so students have a low interest in studying. (Haryanti et al., 2021; Priatna, 2017; Swabnil, B., Mohod, 2025).

The LE-Probale learning model was developed in response to this challenge. This model integrates a technology-based scaffolding approach using "Nila’s Edumath Interactive Mobile Learning" to support the learning process (Ubaidah, N., et al., 2024). The objective is to enhance students’ mathematical literacy by providing structured guidance and interactive tools that facilitate the construction of mathematical knowledge.

The LE-Probale learning model is designed based on theoretical frameworks, including constructivism, contextual learning, and meaningful learning theories from educational scholars such as Piaget, Vygotsky, and Ausubel. This model emphasizes active student participation and encourages learners to construct their own understanding through guided problem-solving, contextual learning, and integration of concepts across various subjects and real-life scenarios.

The purpose of this study is to develop and validate the LE-Probale learning model, evaluate its effectiveness, and implement it across various junior high schools (Ubaidah, N., et al., 2024). This research aims to contribute to the educational field by providing a comprehensive, technology-enhanced learning model that promotes mathematical literacy and prepares students for the challenges of the 21st century.

Several studies (e.g., OECD, NCTM) have shown that students' mathematical literacy plays a pivotal role in their overall academic and personal development. In the context of Indonesian education, recent curriculum changes (regulation of the Minister of Education and Culture Research and Technology number 16 of 2022) have underscored the importance of integrating mathematical literacy as a key learning objective. However, traditional teaching methods are often insufficient to meet these requirements, necessitating the development of new, more effective pedagogical models.

The LE-Probale learning model seeks to address these gaps by using scaffolding techniques to build students' foundational knowledge step-by-step. Through this approach, students are guided to achieve a deeper understanding and application of mathematical concepts, making them more adept at solving complex problems and adapting to various academic and life situations.

The primary objectives of this research are to: Develop the LE-Probale learning model, integrating technology-based scaffolding through Nila's Edumath Interactive Mobile Learning; validate the model through expert review and prototype testing; implement the model in junior high schools and evaluate its effectiveness in fostering mathematical literacy; and analyze the practicality and impact of the LE-Probale model on student learning outcomes.

This research is significant for educators, curriculum developers, and policymakers seeking to enhance mathematical literacy through innovative teaching models. The findings from this study will provide valuable insights into the effectiveness of technology-enhanced learning environments and offer a replicable model that can be adapted for various educational contexts.

The field trial of the LE-Probale learning model was conducted to evaluate its practicality and effectiveness in enhancing mathematical literacy among junior high school students. The trial involved prototype testing at a Junior high school, and was observed by a group of mathematics teachers from the Community of Practitioners.

The field trial results are as follows: (1) Validity of the Model: The LE-Probale learning model was validated by three expert validators in the field of mathematics education. The validators assessed the model's structure, content, and alignment with educational standards. The validation results indicated that the LE-Probale model met the required standards and was deemed valid without the need for significant revisions. Some minor adjustments were made based on validator feedback, leading to the final validated prototype (Prototype II). (2) Practicality: During the field trial, mathematics teachers implemented the LE-Probale learning model in class VIII with various mathematical topics such as integers, probability, and data collection. Observations revealed that teachers were able to follow the model's phases and syntax effectively. Teachers reported that the model was easy to use, and the scaffolding provided by Nila's Edumath Interactive Mobile Learning aided in guiding students through complex concepts. Student engagement was notably higher during sessions using the LE-Probale model compared to traditional methods. Students were more active in discussions and were able to construct and connect mathematical concepts with greater clarity. (3) Effectiveness: The effectiveness of the model was measured using a mathematical literacy assessment at the end of the trial period. Results showed a significant improvement in students' ability to solve problems using mathematical concepts. The analysis of pre-test and post-test scores demonstrated that students made marked progress in understanding and applying mathematical concepts. The use of technology-based scaffolding, such as interactive exercises and digital practice questions, contributed to this improvement. Additionally, student feedback indicated that they found the learning experience more enjoyable and meaningful, as they could see the relevance of mathematics in real-world contexts. (4) Student and Teacher Feedback: Student Responses: Students expressed positive attitudes towards the use of technology in learning mathematics. They highlighted that the interactive nature of Nila's Edumath Interactive Mobile Learning helped them better understand abstract concepts. Teacher Responses: Teachers reported that the LE-Probale model provided a clear structure for lesson planning and execution. The model's focus on scaffolding supported differentiated instruction, allowing teachers to cater to diverse student needs more effectively. (5) Revisions and Final Prototype: Based on the field trial results, minor revisions were made to the LE-Probale learning model to enhance its usability and alignment with classroom realities. Adjustments were made to the sequence of activities and the integration of digital tools to ensure seamless implementation. The revised model, referred to as the final prototype, was then declared practical, effective, and ready for broader implementation.

The field trial demonstrated that the LE-Probale learning model, supported by technology-based scaffolding through Nila's Edumath Interactive Mobile Learning, is a practical and effective approach to fostering mathematical literacy in junior high school students (Ubaidah, N., et al., 2024). The model can be implemented successfully across different mathematical topics and classroom environments, making it a versatile tool for mathematics education. The results provide a strong foundation for the further dissemination and adoption of the LE-Probale learning model in other schools within the Community of Practitioners and beyond.

2. Objectives

The primary objectives of the study on the LE-Probale learning model are: (1) Development of the LE-Probale Learning Model. Create a learning model integrating Project-Based Learning (PBL) and a conducive learning environment. Utilize technology-based scaffolding through Nila's Edumath Interactive Mobile Learning to support student learning. (2) Validation of the Model. Assess the validity of the model through expert reviews and prototype testing. Ensure the model aligns with educational standards and effectively supports mathematical literacy. (3) Implementation in Junior High Schools. Apply the LE-Probale model in real classroom settings to evaluate its practicality. Train teachers on using the model effectively in their mathematics classrooms. (4) Evaluation of Effectiveness. Measure the model's impact on students' mathematical literacy and overall learning outcomes. Use pre-tests and post-tests to assess improvements in problem-solving and concept integration. (5) Analysis of Practicality and Impact. Gather teacher and student feedback to determine the ease of use and engagement levels. Identify challenges and areas for improvement to enhance the model's usability. (6) Scaling and Future Research. Adapt the model for broader use in different mathematical topics and educational settings. Explore the long-term effects of the model and potential enhancements through additional technological tools.

3. Methods

Development of the LE-Probale learning model utilized a research and development (R&D) approach, which modified the Plomp model (1997) to create a comprehensive framework for designing, testing, and implementing an innovative learning model. The method was divided into five key phases: Initial Investigation, Design, Realization, Testing and Evaluation, and Implementation. Each phase was structured to ensure that the learning model was systematically developed, validated, and refined to enhance mathematical literacy among junior high school students.

1. Initial Investigation Phase

The purpose of this phase was to identify the need for developing the LE-Probale learning model and gather relevant theoretical and empirical foundations. The activities included: Problem Analysis: Conducted a literature review and field study to understand the current state of mathematical literacy among junior high school students and identify the challenges faced in mathematics learning; Theoretical Analysis: Analyzed theories related to mathematical literacy, constructivism, contextual learning, and scaffolding to provide a theoretical foundation for the development of the model; Material Analysis: Identified the content areas and specific mathematical topics (e.g., integers, probability) that would be used in the model's trials; Analysis of Student and Teacher Activities: Examined the activities and roles of both teachers and students in the learning process to determine how the model can support mathematical literacy; Analysis of the Learning Environment: Assessed classroom facilities, resources, and digital tools necessary to implement the model effectively.

2. Design Phase

This phase focused on designing the LE-Probale learning model by formulating its components and theoretical underpinnings. The activities included: Designing the syntax of the learning model, which consisted of five phases: (1) Construct Orientation Phase, (2) Construct Phase, (3) Integrative Phase, (4) Contextual Phase, and (5) Reflection and Evaluation Phase of Mathematical Literacy; Establishing the social system, reaction principles, support system, and instructional impact to support the learning model's syntax; Developing the initial prototype (Prototype I) of the LE-Probale learning model and its learning devices, which included teaching modules, practice questions, and assessment instruments through Nila's Edumath Interactive Mobile Learning.

Realization Phase

The realization phase involved the development and preparation of the LE-Probale learning model's components and learning devices. The following activities were conducted: Developed the teaching modules and practice questions for each phase of the model; Created assessment instruments tailored to measure mathematical literacy; Integrated digital tools (e.g., Nila's Edumath Interactive Mobile Learning) to facilitate scaffolding and interactive learning; The finalized learning devices were compiled as Prototype I of the LE-Probale learning model.

4. Testing, Evaluation, and Revision Phase

This phase aimed to validate the LE-Probale learning model and evaluate its practicality and effectiveness through prototype testing and field trials. The activities included: Prototype Validation: Prototype I was validated by three expert validators with doctoral qualifications in mathematics education. They reviewed the model's theoretical basis, design, and usability. (1) If the model was considered valid without revision, it moved to field trials. (2) If the model required minor revisions, it was revised accordingly to create Prototype II. (3) If the model was deemed invalid, a complete or partial revision was conducted to address the identified weaknesses.

Field Trials: Prototype II was tested in real classroom settings at Junior high school in Indonesia. Teachers and students participated in the trials, and data was collected through classroom observations, mathematical literacy tests, and feedback surveys.

Analysis and Revision: Data from the field trials were analyzed to assess the model's practicality and effectiveness. Necessary revisions were made based on the trial outcomes, leading to the final prototype of the LE-Probale learning model.

5. Implementation Phase

The final phase involved the widespread implementation of the validated and refined LE-Probale learning model. The activities included: 1. Coordination with Community of Practitioners: Coordinated with the Kendal Regency School Practitioner Community to plan and organize workshops for implementing the model in various schools. 2. Workshops and Training: Conducted workshops for teachers. The workshops focused on training teachers to use the LE-Probale model and its supporting materials. 3. Broader Implementation: The LE-Probale model was implemented in the classrooms of trained teachers, and its impact was monitored through regular evaluations and feedback sessions.

The method ensured a rigorous and systematic approach to developing, testing, and implementing the LE-Probale learning model, ultimately establishing its validity, practicality, and effectiveness in enhancing mathematical literacy.

4. Results and Discussion

The development of the LE-Probale learning model is the main activity in this study. The procedure for developing the LE-Probale learning model modifies the design of the Plomp (1997) model development as in Figure 1. Details of activities in the phases of developing the LE-Probale model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning to foster mathematical literacy can be explained as follows.

1. Initial investigation phase.

The activities in this initial investigation are focused on two things, namely the rationalization of the need to develop the LE-Probale learning model and preparing materials to design the development of the model. In detail, the activities carried out in the initial investigation phase are as follows.

a. Problem Analysis. Conducting analysis related to the importance of mathematical literacy (Permendikbudristek No. 16 of 2022; Permendiknas No. 22 of 2006; NCTM 2000; OECD, 2018), analysis of mathematical literacy indicators in junior high school/Islamic junior high school students (OECD, 2018; Cheema, 2018; Garcia, 2019; Sumirattana, S., Makanong, A., & Thipkong, S., 2017; Umbara & Suryadi, 2019; Kusuma, D., Sukestiyarno, YL., Wardono, & Cahyono, AN., 2022; Vera, DS., 2022; Handayani et al., 2021; Yamtinah et al., 2022; Anderson et al., 2001; & Sulistyaningrum, 2021; Schoenfeld, 2016; Mansur, 2018; Pugalee, 2019; Lennink, 2005; Liu et al., 2021; Rahman, 2019; Ojose in Betha, et al: 2018; Abdussakir: 2018; Astuti: 2018).

b. Analysis of theories that support the development of the LE-Probale learning model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning to foster mathematical literacy.

The theoretical analysis is based on mathematical literacy and the development of the LE-Probale learning model. The theoretical studies used are: (1) mathematical literacy; (2) constructivism philosophy; (3) contextual philosophy; (4) Piaget's constructivism learning theory and Vygotsky's theory; (5) Ausubel's meaningful learning theory; (8) understanding of learning models and their characteristics; (9) learning model development theory.

c. Material Analysis, Teaching Modules, Practice questions through Nila's Edumath Interactive Mobile Learning and assessment.

1) Analysis of trial materials for the LE-Probale learning model.

The development of the LE-Probale learning model is free of material, and not tied to certain materials. The determination of trial materials is based on the course of the material according to the Junior High School Education calendar. In the implementation of the model trial, the material used is the integers of junior high school. Analysis of the implementation material of the LE-Probale learning model.

2) The implementation material is determined by each teacher according to the learning implementation material running in each school. After being given a workshop on the concept and development of the LE-Probale learning model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning, teachers implement learning by practicing the developed teaching modules.

3) Analysis of the development of learning tools related to the learning implementation plan which in the independent curriculum is referred to as the Teaching Module, practice questions in the form of Nila's Edumath Interactive Mobile Learning, and assessment.

Analysis of the development of learning devices with the LE-Probale model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning was carried out to find the theoretical basis used. Development of Teaching Modules, supporting practice questions and assessment instruments using references in the Merdeka curriculum. The theory of developing teaching modules used is becoming an effective teacher, according to Wong (in Volkan, 2014), making learning plans by Borich (in Volkan, 2014), characteristics of a well-managed class by Wong (in Valkon, 2014), and the format of teaching modules based on Permendikbudristek 16 of 2022. For the development of student worksheets (practice questions), the theoretical basis is the definition of practice questions by Saka, the substance of practice questions by Michaelis, and the function of practice questions by Kurt (in Toman, 2013). The assessment theory used is Permendikbudristek number 16 of 2022 concerning Learning Assessment Standards.

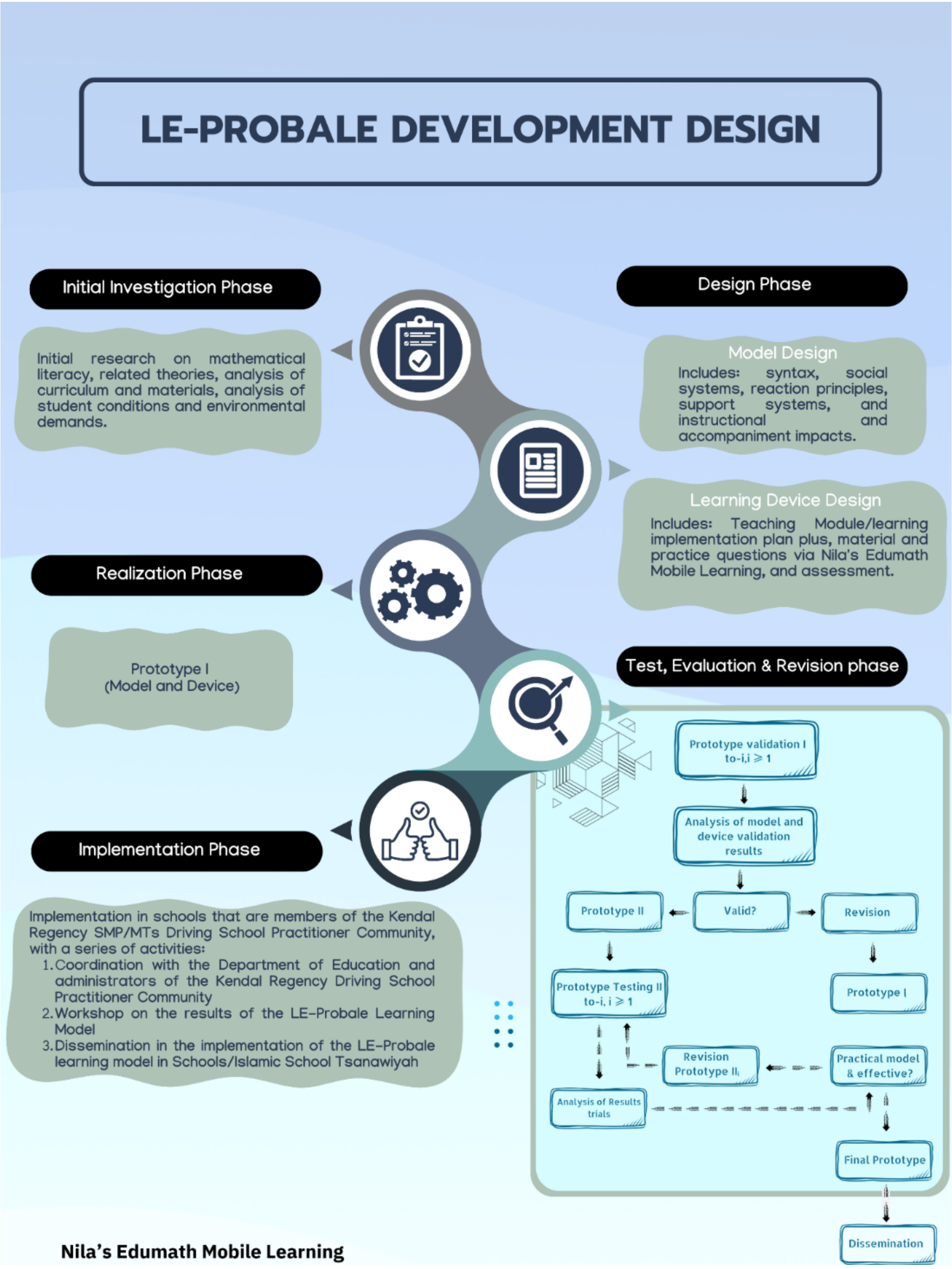

Figure 1. The development of the LE-Probale model

d. Analyzing Student and Teacher Activities

Analysis of the causes of students' less-than-optimal mathematical literacy includes students not being able to link mathematical concepts when constructing new knowledge themselves, not being able to link them to subject concepts, and not being able to link them to everyday life. From the analysis of the causes of less mathematical literacy, it is necessary to identify teachers in learning activities that support the growth of mathematical literacy.

Analysis of student activities that support the growth of students' mathematical literacy include: 1) concentrate on listening to questions asked by the teacher, preparing answers, and delivering answers during Q&A on prerequisite material, 2) concentrate on listening to motivation about the importance of linking mathematical concepts between and among mathematical concepts, with concepts from subjects other than mathematics, and with everyday life, 3) concentrate on listening to the explanation of learning objectives regarding learning indicators, learning models, measures of learning achievement related to mathematical literacy, 4) reading prerequisite material, identifying prerequisite material, identifying prerequisite material that has not been understood and asking, answering lead questions from the teacher related to prerequisite material that has not been understood when encountering prerequisite material, 5) prepare prerequisite materials and receive practice questions, individually construct new concepts starting from prerequisite materials by working on practice questions, ask for ideas when having difficulty constructing, conclude the truth of the new concepts found by providing reasons when constructing, 6) presenting the results of their construction, other students respond, aligning their perceptions of the given bait ideas, emphasizing the correct concepts, 7) find connections between new concepts that have been discovered and concepts other than mathematics subjects; each student is involved in discussions and provides input, 8) find connections between new concepts that have been discovered and everyday life, participate in discussions and ask for and provide input, 9) actively participate in activities to conclude learning by recalling the activities of constructing, relating them to other subjects, and relating them to everyday life.

Meanwhile, teacher activities carried out to support the growth of students' mathematical literacy include: 1) Identifying classroom facilities, learning facilities, and classroom environment, 2) preparing and facilitating comfortable, safe and enjoyable classrooms, 3) provide provocative questions to measure knowledge and explore students' abilities in mastering prerequisite material and obtain initial diagnostic results regarding students' mastery of the material, 4) provide motivation on the importance of linking inter and inter-mathematical concepts, between mathematical concepts and concepts in subjects other than mathematics, and between mathematical concepts and everyday life. 5) convey learning objectives by conveying learning indicators, learning models, achievement measures related to mathematical literacy indicators, 6) Facilitate students in directing practice questions on Android smartphones, students use, read prerequisite materials, identify prerequisite materials, ask about prerequisite materials that have not been understood, explain prerequisite materials that students have not understood by providing trigger questions, 7) facilitate students individually when constructing new knowledge by using practice questions, providing ideas when students have difficulties, asking students to conclude the truth of new concepts that have been discovered, 8) guide students to present the results of their construction, ask other students to respond, provide ideas to align perceptions, emphasize the correct concept when, 9) Facilitate students to find connections between new concepts that have been discovered and concepts other than mathematics, ask each student to participate in discussions and provide input, provide ideas for those who have difficulty, 10) Facilitate students to find connections between new concepts they have discovered and everyday life, ask students to participate in discussions and provide input, provide ideas for those who have difficulty, 11) guide students to conclude related learning about construction activities, link mathematical concepts with other subjects besides mathematics, and link them to everyday life, 12) carry out reflection by ensuring that students have mastered the learning material by giving short oral questions, asking about material that students have not understood, giving individual final learning test questions, 13) provide follow-up learning by giving homework related to the material that has been studied and asking students to prepare the material that will be studied in the next meeting.

e. Analyzing the Learning environment

Identifying classroom facilities, learning facilities, and classroom environment that can be used to help learning so that it can foster mathematical literacy. For classroom facilities needed are tables and chairs that are easy to carry out class dynamics during discussions, laptops, android smartphones and LCDs. Chairs and tables that are easy to move make it easier for students when forming groups to discuss linking concepts that have been found with other subjects besides mathematics and with everyday life. Laptops and LCDs are used to display learning powerpoints, especially contextual image media to help students find prerequisite materials, construct, integrate and contextualize.

The learning tools needed include teaching modules, practice questions, reading materials, questions, markers, rulers, whiteboards, math literacy tests, and student assignments. Teaching modules with the implementation of the LE-Probale learning model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning are important for teachers as preparation for teaching and as a guide during learning. Practice questions are made to support learning with the LE-Probale model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning used when constructing to find new concepts, linking concepts that have been constructed with concepts in subjects other than mathematics and linking them to everyday life. Reading materials are used to find prerequisite material before constructing new concepts.

Questions are prepared and used when exploring prerequisite material for initial learning activities, facilitating students when constructing, integrating and contextualizing, and used when concluding and reflecting in closing learning activities. Markers, rulers and whiteboards are used when students present the results of their work from constructing, integrating and contextualizing. A mathematical literacy test is used to measure students' mathematical literacy at the end of learning. Student assignments are given at the end of learning to provide follow-up to the material studied.

The classroom atmosphere needed to support learning using the LE-Probale model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning to foster mathematical literacy is a conducive classroom atmosphere, and student motivation to be mentally prepared, dare to express opinions, and rewards from the teacher. The expected conducive classroom atmosphere is a calm atmosphere without any noise that interferes with learning, and students are mentally ready to follow the learning. Motivation during learning is always given to students to dare to express their opinions when finding new concepts, and presenting the results of integration and contextual discussions. No less important in learning, teachers must be able to provide rewards for students who have expressed their opinions.

2. Design Phase.

Activities in the design phase are focused on activities to design the LE-Probale learning model. The LE-Probale learning model is designed by considering indicators of mathematical literacy.

3. Realization Phase.

The activities carried out in the realization phase are the development of the LE-Probale learning model by formulating syntax based on theoretical studies to foster mathematical literacy. The syntax of the LE-Probale learning model consists of five phases, namely: (1) construct orientation phase, (2) construct phase, (3) integrative phase, (4) contextual phase, and (5) reflection and evaluation phase of mathematical literacy. After the syntax is formulated, the next step is to formulate a social system, reaction principle, support system, instructional impact and accompanying impact to support the syntax with the aim of fostering mathematical literacy.

After formulating the model components based on theoretical studies of syntax, social systems, reaction principles, support systems, and instructional and accompanying impacts, the next step is to realize the LE-Probale model learning device through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning. The learning devices developed include (1) teaching modules (2), practice questions in the form of Nila's Edumath Interactive Mobile Learning (3), and mathematical literacy assessment instruments (4). The LE-Probale learning model and the learning devices that have been developed are hereinafter referred to as prototype I.

4. Testing, evaluation and revision phase.

In this phase, the focus of the activities carried out is the validation and field testing of prototype I, namely the LE-Probale learning model and its learning tools. Details of the activities carried out in this phase are as follows. a. Prototype Validation I. Validation is carried out with the aim of determining whether the developed model is valid or not. During the validation of prototype I, there are two activities carried out, namely validation activities and analysis of validation results. The provisions and rules carried out in the two activities can be explained in detail as follows.

1) Validation activities, carried out by providing prototype I consisting of the LE-Probale learning model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning and learning devices that have been approved by the three supervisors to 3 expert validators to be assessed based on the theoretical framework using model and device validation instruments. The three expert validators are in addition to the supervisor (promoter, co-promoter, and promoter member) who have academic doctoral qualifications in the field of mathematics education. The three expert validators come from different universities.

2) Analysis of the results of prototype I validation, if the results of this analysis provide the following results: a) valid without revision, then the activity is continued by conducting a field trial. b) valid with revision, then a small revision was made to prototype I of the LE-Probale model through scaffolding based on technology in the form of Nila's Edumath Interactive Mobile Learning and the result is called prototype II of the LE-Probale model through scaffolding-based on technology in the form of Nila's

Edumath Interactive Mobile Learning. c) If any of the models or devices are in the invalid category, then Prototype I is invalid. Further revisions are made, with the following provisions. (1) Ifthe model and device are in an invalid category, then a complete revision is carried out on Prototype I, namely a revision of the model and learning device. The result is called prototype Ii (for i ≥ 1) of the LE-Probale scaffolding model based on technology in the form of Nila’s Edumath Interactive Mobile Learning. (2) If one of the models or devices is in an invalid category, then a partial revision is carried out, namely a revision of the invalid part. (3) If there are any invalid model components, then the model is invalid, and partial revisions are made to the invalid model components, and at the same time the learning devices so that they are in accordance with the revision.

The result of the revision is called prototype Ii (for i ≥ 1) of the LE-Probale scaffolding-based on technology learning model in the form of Nila’s Edumath Interactive Mobile Learning. If there is a case of invalid analysis results, then prototype Ii (for i ≥ 1) of the LE-Probale model through scaffolding based on technology in the form of Nila’s Edumath Interactive Mobile Learning needs to be validated again by an expert validator. If the revision is only partial, for example, the analysis result of one of the model components is invalid, then validation is carried out on the revised part. There is a possibility of a validation activity cycle. The prototype that has been validated from the results of this validation activity will produce prototype II.

b. Conducting Field Trials.

Prototype II was then tested in the field at a Junior high school in Indonesia, Central Java. The main purpose of the field trial was to determine whether the developed model was practical and effective.

Activities carried out during the field trial are as follows:

1) Test prototype II of the LE-Probale model through scaffolding based on technology in the form of Nila’s Edumath Interactive Mobile Learning which has been declared valid.

2) Collect data using research instruments and analyze the trial results.

3) Conduct revisions based on the results of the trial analysis and produce prototype IIi for i = 1, 2, 3, …

4) Conducting prototype IIi trials, collecting data, and analyzing to obtain the final prototype, namely the LE-Probale learning model and tools through scaffolding based on technology in the form of Nila’s Edumath Interactive Mobile Learning, which is practical and effective for fostering mathematical literacy.

In the implementation of the learning trial, it was carried out by mathematics teachers at Junior high school in Indonesia by the instructor in class VIII, and observed by six junior high school mathematics teachers as members of the Community of Practitioners at the driving school in Kendal Regency, Central Java. A schedule of observation officers was made and for each learning session, it was observed by two observers. The first observer observed the teacher's activities and the second observer observed the students' activities and the classroom atmosphere. At the end of the cycle, a mathematical literacy learning outcome test was conducted and students were asked to fill out a student response questionnaire. If the results of the data analysis meet the practical and effective criteria, the trial is stopped. If it is not practical or effective, then a revision is made to the part of the model or device that is considered to be the cause of impracticality or ineffectiveness, and the trial is continued until it meets the practical and effective criteria. The results of the trial model that is already practical and valid are then referred to as the final prototype.

5. Implementation Phase

The final prototype, namely the LE-Probale learning model and tools that are valid, practical, and effective, is then implemented widely.

Product Practicality

The practicality of a learning model refers to its ease of use, alignment with educational needs, and the feasibility of its implementation in real-world classroom settings. For the practicality of a product of the LE-Probale model, several factors should be considered: (1) Ease of Implementation for Teachers: Teachers should be able to understand and implement the learning model without extensive additional training or resources. A practical learning model includes clear guidelines, teaching modules, and adaptable lesson plans that fit within the existing curriculum. This ease of implementation ensures that the model can be adopted by a wide range of educators, regardless of their experience level or access to resources. (2) Alignment with Curriculum Standards: The learning model must align with national or regional curriculum standards, making it practical for use in various educational contexts. For example, the LE-Probale model, discussed earlier, was designed to comply with the Indonesian educational standards, making it more readily acceptable by educators and administrators.

5. Conclusion

The development and implementation of the LE-Probale learning model have demonstrated its effectiveness and practicality in fostering mathematical literacy among junior high school students. This learning model, which integrates technology-based scaffolding through "Nila’s Edumath Interactive Mobile Learning," provides a structured approach that guides students in constructing mathematical knowledge and applying it to real-world contexts.

The research, conducted through a modified Plomp model (1997) approach, revealed several key findings: 1. Validity: The LE-Probale learning model was validated by expert reviewers and found to be theoretically sound and pedagogically appropriate for enhancing mathematical literacy. The model's structure, content, and implementation procedures align with current educational standards and effectively support student learning. 2. Practicality: Field trials at Junior high school in Indonesia, showed that the LE-Probale learning model is practical for use in classroom settings. Teachers were able to easily implement the model, and the technology-based scaffolding provided by Nila’s Edumath Interactive Mobile Learning facilitated the teaching process. Students actively participated in lessons and were able to construct mathematical knowledge with minimal guidance. 3. Effectiveness: The model significantly improved students’ mathematical literacy, as indicated by the results of pre-test and post-test scores. Students showed better problem-solving skills, increased engagement, and a greater ability to connect mathematical concepts with everyday situations. The use of interactive digital tools made learning more meaningful and relevant for students. 4. Teacher and Student Feedback: Both teachers and students provided positive feedback on the LE-Probale learning model. Teachers found the model to be a useful framework for planning and conducting lessons, while students appreciated the interactive and contextual nature of the learning activities. 5. Scalability and Adaptability: The LE-Probale model was successfully implemented across various mathematical topics and grade levels, demonstrating its flexibility and adaptability. The model's technology-based approach allows it to be applied in different learning environments and with diverse student populations.

Based on these findings, it can be concluded that the LE-Probale learning model is an effective and practical approach for enhancing mathematical literacy in junior high schools. The integration of technology-based scaffolding supports students in constructing mathematical knowledge and applying it in meaningful ways, making it a valuable tool for mathematics education.

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