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Development of PBL-STEM-Based Edcafe Application Learning Design in an Effort to Improve Students' Numeracy Skills and Overcome Mathematical Anxiety

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Abstract: Indonesian education grapples with persistent challenges, including students' mathematical anxiety and suboptimal numeracy skills. This study concurrently addresses these issues through the development and validation of a PBL–STEM-integrated Edcafe application learning design**.** Aimed at high school students, this innovative approach seeks to mitigate mathematical anxiety while enhancing numeracy competencies**.** Adopting a Research and Development methodology framed by the ADDIE model, the study produced a comprehensive application design tailored to deliver problem-based learning within contextualized environments. Validation outcomes were highly favorable: media experts rated the statistics learning materials at 88.33% (highly valid category), material experts at 91.66% (very valid category), and practitioners at 94.09% (very practical category). Small-group trials confirmed the suitability for implementation, while large-group testing indicated that 42.86% of students strongly agreed and 53.57% expressed interest in using the Edcafe application. Collectively, the findings and expert endorsements underscore the learning materials' strong validity and utility for mathematics instruction.

Keywords: Edcafe; Learning design; Mathematics Anxiety; Numeracy Skills; PBL-STEM.

Introduction

Students' numeracy skills are a crucial aspect of mathematics education in facing the challenges of the 21st century (Adelabu & Mudadigwa, 2025; Rahmi & Saefudin, 2024). Numeracy skills are considered key for students to access and understand the modern world, where an emphasis on the application of mathematics relevant to everyday life helps students develop self-confidence and critical thinking skills (Rahmi & Saefudin, 2024; Yunarti & Amanda, 2022). Improving student numeracy is a priority to support learning outcomes and global competitiveness, especially considering the low ranking of Indonesian students in the PISA (Nur et al., 2024; Susanti, 2024). Students' numeracy skills are influenced by many factors, one of which is students' mathematical anxiety (Adelabu & Mudadigwa, 2025; Harahap & Surya, 2017; Mutik & Agoetanto, 2025; Nur et al., 2024; Ramadhan et al., 2024). Mathematics anxiety has a significant negative relationship and influence on students' mathematics learning (Adelabu & Mudadigwa, 2025; Putra & Yulanda, 2021; Safitri et al., 2022)

Attention to students' numeracy skills is still lacking, both from students and teachers (Lindang & Wewe, 2024; Wulandari et al., 2023). Many students do

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not fully recognize the importance of numeracy skills in everyday life, and teachers often do not pay sufficient attention to developing students' numeracy skills, resulting in ineffective learning processes (Hakim & Adirakasiwi, 2021; Wulandari et al., 2023). Many teachers do not fully understand how to integrate numeracy into daily learning, and teachers need to be more creative in designing learning activities that involve numeracy and provide meaningful learning experiences for students (Annisa et al., 2023; Muhayati et al., 2023). Because students' numeracy abilities are influenced by mathematical anxiety (Mutik & Agoetanto, 2025), this is a mathematics learning problem that should not be underestimated by teachers and must be addressed immediately (Novianti et al., 2023; Nurhidayat & Djidu, 2022). Students' low self-confidence in their mathematical abilities is one of the causes of mathematical anxiety (Sholichah & Aini, 2022). This can occur because of the learning model used by teachers, as most teachers in schools only use simple learning media, such as whiteboards, printed books, and projectors as presentations in the learning process (Habibi & Suparman, 2020).

One solution to this problem is to train thinking skills through appropriate learning models (Doyan et al., 2024; Maskur et al., 2020). This can be attempted by developing application designs as technology-based learning media that are integrated with PBL-STEM to facilitate numeracy skills and overcome students' mathematical anxiety (Abdullah et al., 2015; Efendi & Wijaya, 2016; Viana et al., 2023; Vistara et al., 2022), which is in line with the results of research on the PBL-STEM model showing that it can increase students' critical thinking skills (Waluyo, 2023). The implementation of STEM-based learning can also improve student learning outcomes and motivation (Raisah et al., 2023).

The use of technology in education as a learning aid provides a richer (Sima et al., 2020) and more enjoyable learning experience to students (David & Weinstein, 2023). The integration of technology as a learning medium can also influence the success of mathematics learning (Nuri, 2019). The use of technology based simulations can also improve problem-solving skills (Hidayati et al., 2025). The learning media that can be used is the Edcafe application integrated with PBL-STEM. Edcafe can be integrated into learning as 1) a tool for teachers in making plans, creating presentations, interactive quizzes, and collecting various relevant learning resources; 2) as an independent learning medium, students can access teaching materials, work on quizzes, and interact with chatbots independently outside of class hours; 3) to provide resources, facilitate information gathering, and even as a platform for presenting student project results; 4) this application emphasizes formative assessment strategies, which allow teachers to provide timely feedback on student progress. This feature allows students to identify strengths and areas that need improvement without exam pressure and will address student anxiety. The use of technology in learning reduces the level of mathematics anxiety in students and improves student learning achievement (Ersozlu, 2024). Increasing numeracy skills can be achieved by implementing PBL-STEM based mathematics learning and has an effect on students' mathematics anxiety (Abdulah et al., 2022). Furthermore, integrating computer software into mathematics education can enhance motivation and provide crucial assistance to students struggling with mathematical concepts, thereby mitigating anxiety (Adelabu & Mudadigwa, 2025).

This study therefore investigates how the integration of technology-based learning, specifically through the Edcafe application and PBL-STEM, can mitigate mathematics anxiety and improve numeracy skills, particularly in the context of Indonesian junior high school students where critical thinking and mathematical abilities remain low (Jiménez-Gaona & Vivanco-Galván, 2024; Pramasdyahsari et al., 2023). This approach aligns with the growing body of evidence suggesting that technology, when strategically incorporated, can significantly enhance mathematics education by providing engaging and interactive learning experiences, thereby fostering a more positive attitude towards the subject (Nuri & Zikriana, 2023). The visual components and interactive nature of applications like Desmos further aid students in comprehending mathematical concepts, moving beyond rote memorization to a deeper understanding of underlying principles (Nuri et al., 2025). Such innovative teaching methods, which include student-centered and collaborative learning, as well as the use of interactive technologies, are crucial for promoting positive attitudes towards mathematics and statistics (Cujba & Pifarré, 2024). This shift from traditional, lecture-based methods to technology-enhanced pedagogical approaches is essential for addressing mathematics anxiety and improving numeracy outcomes, particularly when supported by educational interventions that motivate students through software (Adelabu & Mudadigwa, 2025; Atoyebi & Atoyebi, 2022).

Method

Research Type and Development Model

This study is a Research and Development project focused on creating a learning design for the Edcafe application. The design integrates Problem-Based

Learning with Science, Technology, Engineering, and Mathematics to enhance students' numeracy skills and alleviate their mathematical anxiety. For this purpose, the ADDIE model was selected, encompassing five stages: Analysis, Design, Development, Implementation, and Evaluation. This model is particularly suitable, as it supports systematic development of learning products from needs identification to thorough evaluation of effectiveness and feasibility.

Development Procedure

Analysis Stage

The analysis stage aims to identify specific needs for developing the learning design. According to (Branch, 2010), the initial stage of the ADDIE development model is analysis, which consists of identifying existing learning problems, objectives, and needs. The overall series of activities begins with an analysis of student and teacher needs through initial observations and interviews to identify relevant learning materials. Next, challenges faced by students, particularly in numeracy, levels of mathematical anxiety, and the need for technology-based media, are identified. Furthermore, an analysis of the curriculum and materials is conducted to determine core competencies and achievement indicators related to numeracy skills. The final stage involves formulating materials suitable for integration with PBL-STEM and applying them to Edcafe.

Design Stage

In this phase, a conceptual framework and product blueprint are formulated based on the findings from the analysis stage. Key activities encompass defining learning objectives, selecting instructional strategies, and identifying suitable media for content delivery (Molenda, 2003). Additional tasks include developing the PBL-STEM learning framework (Abdulah et al., 2022; Waluyo, 2023) especifically, crafting a learning sequence that incorporates the five PBL phases and integrates STEM elements as well as designing the Edcafe application and instruments for expert validation, product trials, and student response assessments (Lee & Owens, 2004)

Development Stage

The development stage is the implementation of the previously developed design (Branch, 2010). This involves developing and validating a prototype of the Edcafe application learning design. Development refers to the process of producing and testing the validity of all designed learning resources. This includes prototype development, supporting materials creation, and expert validation (Lee & Owens, 2004). Activities in this stage include design realization, namely the development of all Edcafe application components based on the blueprint. The next crucial stage is expert validation, which involves testing the product's feasibility by material experts, media/learning design experts, and mathematics teachers as practitioners. Following the validation process, the first product revision is conducted based on input and suggestions from experts and practitioners.

Evaluation Stage

This final stage aims to determine the feasibility, practicality, and effectiveness of the Edcafe application learning design developed. Activities at this stage begin with a Small Group Trial involving 6–10 students to obtain initial feedback on practicality. Next, a field trial is conducted on a larger group of students (one class) to test the effectiveness of the Edcafe learning design in improving numeracy skills and addressing students' math anxiety. This stage concludes with data analysis and final revision, which analyzes the data from the field trial (feasibility, response, and effectiveness) and then makes final revisions before the Edcafe learning design is declared a feasible and effective final product.

Research Subjects

The research subjects were categorized into three principal groups: expert validators, mathematics teachers acting as practitioners, and students from SMA 1 Lhoksukon with prior exposure to statistics. Expert validators and teachers evaluated the product's feasibility, whereas students functioned as participants in field trials to assess the Edcafe application's design efficacy and quantify mathematical anxiety levels. The deliberate selection of students from SMA 1 Lhoksukon, specifically those possessing foundational statistics knowledge, guaranteed that the app's effectiveness was appraised within a cohort relevant to its content.

Data Collection Techniques

Data were gathered using non-test instruments, encompassing observations to evaluate initial research needs. In addition, focus group discussions with teachers were facilitated to elicit detailed feedback on the developed product. Questionnaires were utilized to acquire data on product validity from experts, practicality from responses by students and teachers, and levels of student mathematical anxiety.

Data Analysis Techniques

Data analysis was conducted using descriptive analysis techniques. Non-test data, namely questionnaire scores, were analyzed to determine the product's validity and practicality. The Edcafe application design product was declared valid if the

expert and teacher assessments fell into the valid category. The product was considered practical if the student and teacher questionnaire responses fell into the good/practical category. The results of this descriptive analysis served as the basis for product revisions.

Results and Discussion

The development of instructional materials adhered to the ADDIE model, encompassing the analysis, design, development, and evaluation phases. In the analysis phase, an examination of prevailing learning processes was undertaken. Observations indicated that students faced challenges in addressing statistics-related problems, attributable to the multi-step procedures and requisite precision, which frequently induced anxiety (Corno, 1988; Rozgonjuk et al., 2020). Accordingly, accessible media enabling students to tackle contextual problems proved essential. The Edcafe application functions as supplementary instructional media, offering diverse features that facilitate student learning. These features include a range of interactive elements designed to mitigate math anxiety and promote deeper engagement with statistical concepts (Ivan & Maat, 2024). The subsequent design phase focused on structuring these interactive elements and integrating the problem-based learning methodology, ensuring alignment with pedagogical best practices (Alfan et al., 2025). The development phase then involved creating the actual interactive e-module, incorporating a STEM-PBL approach to enhance critical thinking and learning outcomes, which was subsequently validated by subject matter and media experts (Liunima & Widiyatmoko, 2025).

The design phase, the second stage of the ADDIE model entails formulating the Edcafe application as an accessible learning platform, incorporating interactive quizzes that provide immediate feedback to learners (Adhelacahya, 2023) and a chatbot to support problem-solving. Edcafe constitutes an innovative AI tool that facilitates educators in creating and managing high-quality instructional content. Featuring a personalized chatbot, learning resources, flashcards, interactive assessments, and a slide generator, Edcafe distinguishes itself from other AI platforms (Rakhmawati et al., 2025). Educators may submit their materials for evaluation, enabling the tool to produce tailored content. The developed instructional materials are specifically aligned with the subject of statistics (Nuri et al., 2019)The integration of artificial intelligence in instructional design enhances learning outcomes and facilitates adaptive learning (Motlaq et al., 2012). This integration of AI features into the learning platform serves to enhance engagement and provide adaptive learning pathways tailored to individual student needs (Anisah et al., 2024; Merino-Campos, 2025). This design process often involves creating a comprehensive assessment blueprint, integrating interactive functions for problem-solving tasks, and garnering feedback from various experts to refine the application's pedagogical utility and technical soundness (Nuri et al., 2025; Rosyidi et al., 2024)). Further, the incorporation of AI in educational settings, particularly through tools like Edcafe, is crucial for fostering critical thinking skills, a vital component of modern education (Shukor & Osman, 2025). AI-powered platforms can significantly contribute to personalized learning by offering tailored educational experiences that adapt to individual student needs and learning styles (Gutierrez et al., 2025).

Figure 1. Design product in Edcafe

The instructional materials incorporated statistical concepts presented through slide decks, complemented by student worksheets featuring an integrated assessment grader in the Edcafe platform intended to optimize students' problem-solving skills. Upon submission of their assignments, students obtained immediate feedback encompassing not only grades but also corrections aligned with established achievement standards (Muljana et al., 2023). This feedback was supplemented with targeted suggestions, comments, and remedial actions (Dwiningsih et al., 2024). In the development phase, the designed media were realized as the Edcafe application prototype. Validation ensued through evaluation by media and material experts to confirm the learning media's feasibility. Their recommendations guided revisions, facilitating subsequent field testing. The expert validation results are detailed in Table 1. This expert validation process is crucial at the implementation stage, ensuring alignment with continuous improvement objectives (Zulkepli et al., 2024). This rigorous validation process ensures that the Edcafe application is not only pedagogically sound but also technically robust, addressing both content accuracy and user experience. The validation process, encompassing evaluations by material and media experts, yielded high ratings for the Edcafe module's theoretical soundness and internal consistency, aligning with similar findings in educational tool development (Perdana et al., 2025).

Table 1. Expert table validation

Aspect Assessed	Percentage %	Qualification
Media	91.66	Very valid
Content	88.33	Very valid
Average	90.00	Very valid

As indicated in Table 1, the Edcafe application media achieved very valid ratings in both assessed aspects: 91.66% for the media component and 88.33% for the material component. These findings confirm that the application's media design is appropriate for implementation with students, subject to the proposed enhancements.

The practicality of the Edcafe application media was assessed through practitioner validation results**.** Data gathered from practitioners informed the evaluation of the media's usability prior to field testing. This validation process confirms the application's robustness, user-friendliness, and pedagogical appropriateness within its intended educational context**.**

Table 2. Practitioner Validation

Validator	Percentage %	Qualification
Practitioner 1	97.22	Very valid
Practitioner 2	95.83	Very valid
Practitioner 3	94.44	Very valid
Practitioner 4	84.72	Very valid
Rata-Rata	90.00	Very valid

Table 2 indicates that the Edcafe learning media design demonstrates high practicallity for implementation in educational activities. This elevated practicality rating highlights Edcafe's capacity to effectively bolster pedagogical processes, particularly by fostering interactive and constructivist learning experiences.

Following validation, the prototype underwent preliminary small-scale testing with six students, purposefully selected to represent high, medium, and low proficiency levels. Participants were tasked with interacting with the Edcafe application to familiarize themselves with its interface and complete the associated learning tasks**.**

Analysis of questionnaire responses from the small-scale trial indicated that the majority of participants exhibited strong interest in incorporating Edcafe into their learning activities. Key features, such as teachers' ability to embed images in lessons and students' access to a teacher-supervised chatbot that serves as a learning assistant**,** contributed to this positive reception. The trial, conducted with Class X students at SMAN 1 Lhoksukon**,** aimed to evaluate the practicality of deploying the developed media design within the Edcafe application.

Table 3. Student response percentage

Statement	Choice Answer			
	SS %	S %	KS %	TS %
Edcafe application media use language which easy Understood	57.14	42.86	0.00	0.00
Design edcafe application media Which used own Appearance Which interesting	35.71	64.29	0.00	0.00
Activity instructions in the edcafe application media are clear, so that make things easier in do all activity	42.86	53.57	3.57	0.00
Use edcafe application media make it easier for understand material learning	35.71	57.14	7.14	0.00
Application media edcafe increase motivation study	42.86	50.00	7.14	0.00
Shape, model and font size used easy for read	42.86	53.57	3.57	0.00
Application media edcafe load questions exercise which can test knowledge about statistics	39.29	60.71	0.00	0.00
I like study with using the edcafe application media	46.43	50.00	3.57	0.00
Use of application media edcafe trains for put forward opinion	32.14	67.86	0.00	0.00
Edcafe application media makes I become more active in study	60.71	35.71	3.57	0.00
Edcafe application media makes lesson mathematics become more interesting for studied	42.86	50.00	7.14	0.00
The presentation style of the Edcafe application media is fun.	50.00	50.00	0.00	0.00
The use of the edcafe application media makes you more curious to learn.	28.57	71.43	0.00	0.00
I understand all the material contained on the edcafe application media	39.29	60.71	0.00	0.00
Edcafe application media makes it easier to learn quadratic equation material	57.14	42.86	0.00	0.00
The clarity of the images on the edcafe application media makes the learning process becomes easier	53.57	42.86	0.00	3.57
Edcafe application media is easy to access	50.00	46.43	3.57	0.00

Statement	Choice Answer			
	SS %	S %	KS %	TS %
Activities contained in the edcafe application media improve numeracy skills.	46.43	53.57	0	0.00
The media content of the edcafe application is very useful for me.	46.43	50.00	3.57	0.00
I am very interested when using the edcafe application media	42.86	53.57	3.57	0.00

The concluding phase of the ADDIE model entails evaluation. In this phase, the researcher distributed a questionnaire to students to assess their feedback following their use of the Edcafe application. The results from this questionnaire are displayed in Table 3.

Table 3 presents the percentages of student responses regarding the Edcafe media, derived from the questionnaire administered after participants engaged with the Edcafe application. The evaluation covered key aspects including media display, image clarity, presentation style, ease of use and accessibility, language and content quality, as well as the embedded learning activities. Notably, 42.86% of students strongly agreed and 53.57% agreed that the Edcafe application media is highly engaging for mathematics instruction. Moreover, the implementation of Edcafe media effectively mitigates students' mathematics anxiety, as illustrated in the subsequent table. This positive reception by students underscores the practical utility and appeal of the Edcafe application, aligning with findings that emphasize the importance of engaging and accessible learning resources (Dosinaeng et al., 2020). Such interactive digital tools, including mobile applications, have demonstrated significant potential in fostering student engagement and improving learning outcomes across various subjects, including mathematics (Mamolo, 2022)

Table 4. Catageries of students' mathematics anxiety

Category of mathematical anxiety levels	Number of students before using Edcafe	Number of students after using Edcafe
Very high	3	2
High	11	8
Moderate	7	8
Low	9	10
Very low	1	2

Table 4 depicts a decline in the number of students categorized under very high and high mathematical anxiety levels following Edcafe implementation, alongside an increase in those with low and very low anxiety. These shifts indicate that Edcafe media contributes to mitigating students' mathematical anxiety, though the magnitude of change remains modest (Atoyebi & Atoyebi, 2022; Polydoros et al., 2025).

Conclusion

Utilizing the aforementioned developmental paradigm, a comprehensive design for the Edcafe application was formulated to deliver problem-based learning within an optimal educational framework. Media experts rated the developed statistics learning materials at 88.33%, categorizing them as highly valid, while material experts awarded a 91.66% score, deeming them very valid. Practitioners assessed practicality at 94.09%, classifying it as very practical. In large-group trials, 42.86% of students strongly agreed and 53.57% agreed that they were interested in using the Edcafe application media, with small-group trial outcomes also deemed suitable for implementation. Corroborated by expert validation and study results, these learning materials demonstrate high validity and effectiveness for mathematics instruction.

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