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Development of e-modules of basic laws of chemistry based on problem-based learning to improve critical thinking skills

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ABSTRACT

Critical thinking is an important aspect of the skills expected in 21st-century learning, especially in chemistry learning. Based on preliminary studies that have been carried out, critical thinking skills are still not practiced in the learning process, and the teaching materials used are still only a few that relate daily life problems to the material. This study aimed to evaluate the validity, practicality, and effectiveness. The ADDIE model was used as the method of this research, 36 students of class X-E of Senior High School 5 Banjarmasin were the subjects of the development research. Data were collected with test and non-test instruments. Analysis of validity, practicality, and effectiveness were the analysis techniques used in this study. The findings of this study are that the e-module has a very high level of validity which is 94.93, very practical with a practicality score of 84.46, and effective with an N-Gain of 81.15. Suggestions for future researchers are that the developed e-modules can be accessed without using the internet and the testing of the developed products can be more than one school.

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INTRODUCTION

Critical thinking is expected to be possessed by every learner as part of 21st-century learning competencies. According to Manik et al., (2020) and Prathiwi & Utami (2019), developing and acquiring critical thinking is important when studying chemistry. Learning should not be limited to mastering the material but also allow learners to develop the life skills they need. Critical thinking is the ability to reason, focusing on making decisions about truth and appropriate action.

The level of critical thinking in Indonesia is still low as shown by data from 2015, 2018, and 2022 that Indonesia is still below the average score of PISA completeness (Kurniawati, 2022; OECD, 2019; Sutrisna, 2021). The PISA results showed three weaknesses of Indonesian students in terms of: (1) applying ideas to real situations, (2) providing clear scientific explanations, and (3) understanding the evidence provided (Arini et al., 2021). PISA results reflect students' understanding of the curriculum and their ability to think critically, interpret information, and solve problems in various life contexts.

Data from preliminary studies conducted at Senior High School 5 Banjarmasin support the conclusion about the low level of critical thinking, namely (1) the critical thinking learning process

is less focused, (2) the teaching materials are still few that relate life problems relevant to the material. According to research by Amijaya et al., (2018) and Priyadi et al., (2018) teacher skills in implementing the learning process are an additional cause of low critical thinking skills, namely the teacher only focuses on delivering learning material so that the learning process tends to be teacher-centered resulting in scientific explanation skills only in the form of a description of a phenomenon.

Manik et al., (2020) and Prathiwi & Utami (2019) state that students must build and master critical thinking skills in chemistry learning. The basic laws of chemistry are one of the chemical materials that require critical thinking skills to learn, but these skills are not used when learning the material. This is explained by research by Fadillah et al., (2022) that students have a passive attitude toward the basic laws of chemistry because they are only given instructions to memorize and solve calculation problems without understanding the concept. Meanwhile, according to Mairoza & Fitriza (2021), the basic chemical law material is very abstract and concrete, so to understand the concept, critical thinking skills are needed. Connecting concepts with everyday life situations can increase understanding of concepts more deeply and support the learning process of the material being studied.

Based on a preliminary study at Senior High School 5 Banjarmasin, 88.5% of students had difficulty understanding chemistry materials with the teaching materials used and 69.2% of students looked for other supports to help them understand the material studied. Teaching materials and learning models used in learning have an important role in supporting learning through the Merdeka Curriculum. Developing teaching materials with appropriate learning models is a way for a teacher to motivate students to understand concepts and use them in everyday life (Dibyantini & Sulastri, 2023).

Research conducted by Putri & Sukarmin (2023) states that one way to improve critical thinking skills is with learning models and teaching materials used such as e-modules. Rohmatulloh et al., (2023) stated that the PBL learning model can help students improve critical thinking skills because students are faced with problems that must be solved. On the other hand, e-modules that interestingly present material, related to the real world and interactive help improve critical thinking skills.

Overcoming this, the researcher developed an e-module of basic laws of chemistry based on PBL to improve critical thinking skills. According to Darmayasa et al., (2018) and Mulyadi et al., (2019), learning materials that are systematically organized based on the curriculum and delivered via the Internet and electronic media are known as e-modules. E-modules are equipped with multimedia elements such as audio, video, and animation to enhance the learning experience. On the other hand, problem-based learning requires scientific methods to help students solve real problems relevant to life (Arends, 2008; Fidan & Tuncel, 2019; Susanto, 2020).

Previous research is the basis for taking this e-module development solution, (1) Mawati (2022) stated that problem-based chemistry e-modules effectively improve knowledge, attitudes, and skills so that they are suitable for use as learning resources, (2) Wulandari et al., (2020) found that the problem-based learning model affected critical thinking skills with a significance level <0.05, and (3) research by Izzania et al., (2024) stated that the e-modules developed were effective for equipping students' critical thinking skills. On the other hand, the development of this e-module brings novelty in terms of (1) technological integrity: the use of a platform in the development of e-modules shows the existence of technological integrity in education that reflects efforts to utilize digital technology and (2) the basis used: PBL helps students think critically and solve problems.

This development research certainly contributes to schools, teachers, and students in terms of (1) improving the learning process, (2) additional information related to e-module development, and (3) efforts to improve students' thinking skills. So the purpose of this study is to analyze the aspects of validity, practicality, and effectiveness of e-modules to improve critical thinking skills.

METHOD

Research Design

Figure 1 shows that the ADDIE model was used in this development research (R&D).

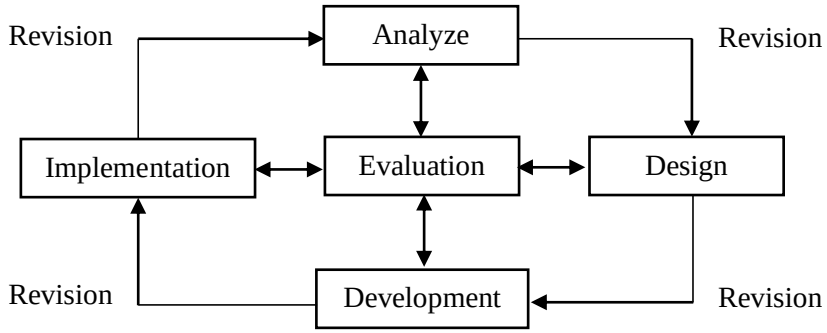

Figure 1. ADDIE Model

The analysis stage involved three types of analysis to start the research, namely (1) performance analysis was conducted to analyze basic problems and critical thinking skills faced in chemistry learning at Senior High School 5 Banjarmasin, (2) analysis of students and teaching material needs to be aimed at understanding the characteristics of students and learning needs at Senior High School 5 Banjarmasin and (3) analysis of facts, concepts, and procedures on learning materials.

The developed product was designed at the design stage. The process carried out, namely (1) collection of reference material for the basic laws of chemistry, (2) e-module framework design, (3) e-module prototype design, and (4) design of research tools and instruments. At the development stage, e-modules were made, and validated, individual and small group trials, and e-module modifications.

The results of the final revision made at the development stage are carried out at the implementation stage in class X-E and the evaluation stage is an action taken at each stage of ADDIE.

Research Subject

The test subjects of this development research were class X-E Senior High School 5 Banjarmasin totaling 36 students.

Instruments and Data Analysis Techniques

There are three types of data collection instruments, namely validity, practicality, and effectiveness instruments. The type of analysis used to evaluate product feasibility is validity analysis. This analysis evaluates 4 aspects, namely the feasibility of content, presentation, language, and media. Then to evaluate how easy the developed product is to use is known as practicality analysis. Meanwhile, the type of analysis used to assess the success of an action is effectiveness analysis. The calculation and assessment criteria for validity, practicality, and effectiveness can be seen as follows Formula 1.

$$Percentage = \frac{Number\ of\ Scores\ Awarded}{Maximum\ Sum\ of\ Scores}\ x\ 100\% \quad (1)$$

The percentage results obtained are then grouped based on the criteria for assessing the validity and practicality of the e-module, which can be seen in Table 1 and 2.

Table 1. Criteria for Validity of E-modules

No.	Persentase Skor Validitas	Criteria	Information
1	85.01 – 100.00	Very Valid	Small Scale Revision
2	70.01 – 85.00	Fairly Valid	
3	50.01 – 70.00	Less Valid	Large Scale Revision
4	≤ 50.01	Invalid	Unusable

(Akbar et al., 2015)

Table 2. Criteria for Practicality of E-modules

No.	Percentage of Practicality Score	Criteria
1	81 – 100	Very Practical
2	61 – 80	Practical
3	41 – 60	Practical Enough
4	21 – 40	Not Practical
5	≤ 20	Not Very Practical

(Akdon, 2015)

Then To determine the effectiveness of the e-module, the N-gain Formula 2 according to Meltzer was used.

$$<g>= \frac{S_{post}-S_{pre}}{S_{maks}-S_{pre}} \quad (2)$$

Table 3. N-Gain Score Categories

No.	N-Gain Coefficient	Criteria
1	n > 0.7	High
2	0.3 ≤ n ≤ 0.7	Medium
3	n < 0.3	Low

(Ramdhani et al., 2020)

Furthermore, the N-Gain values obtained were put into the N-Gain effectiveness assessment category as follows.

Table 4. N-Gain Effectiveness Interpretation Categories

No.	N-Gain	Criteria
1	> 76	Effective
2	56 – 75	Effective Enough
3	40 – 55	Less Effective
4	< 40	Ineffective

(Hake, 1999)

RESULTS AND DISCUSSION

Results

The Results at the analysis stage are as follows: (1) performance analysis: the conclusion obtained is that the cause of low critical thinking skills is that there is less practice in working on questions that refer to this variable and less confronted with issues that occur in everyday life, (2) analysis of students and teaching material needs: the conclusion obtained is that the skill level of students varies, then the teaching materials used make 88.5% of students feel difficult in learning chemistry, and 69.2% of students look for additional materials to help understand the material, (3) the analysis of facts, concepts, and procedures of the subject matter resulted in basic findings that can be used to formulate and set learning objectives in the e-module.

In the design stage, e-module design activities are carried out. The design process consists of four stages: (1) collection of reference material for the basic laws of chemistry, (2) e-module framework design, (3) e-module prototype design, and (4) design of research tools and instruments. This stage produces an e-module framework that is ready to be used in the next stage.

Creation/production, validation, individual and small group trials, and e-module modification are the development stages of this research. This process resulted in e-modules that are ready to be tested and research instruments that can be used. The materials in the e-module are arranged based on the ATP of chemistry subjects. The e-module sections developed are classified into: (1) the cover page contains the logo, base, material, and class information, author's identity, and relevant visualizations, (2) the beginning of the e-module contains an explanation of learning outcomes and learning objectives, an explanation of the features contained in the e-module, an explanation of the learning model and concept map, (3) the core part (learning activities) contains the stages of the

learning model, material, examples of daily life interests with material, example questions, independent practice and a summary, and (4) the closing section contains feedback, glossary, bibliography and author's bio. The following are the results of the development stage.

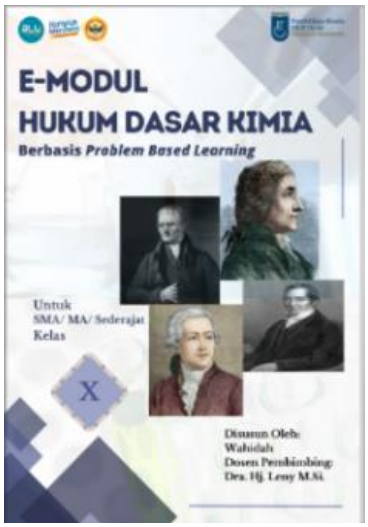

Figure 1. Cover Page

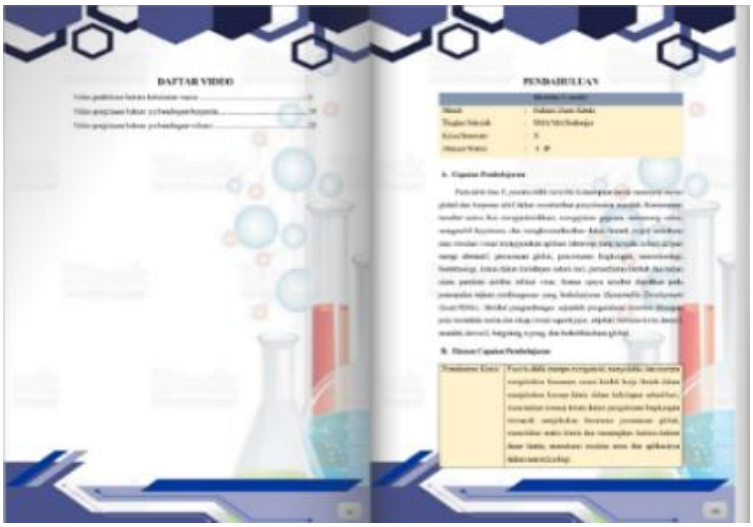

Figure 2. The Beginning of the E-module

Figure 3. Core Section (Learning Activities)

Figure 4. Closing Section

Evaluating learning products requires five experts to analyze the validity of the e-module. The aspects analyzed in this test are the feasibility of content, presentation, language, and media which consists of 45 questions. The results of the e-module validity test are shown in Table 5.

Table 5. Results of the E-module Validity Test

No.	Aspects	Validator					Average	Percentage
		I	II	III	IV	V		
1	Contents	60	58	57	60	52	57.4	95.67
2	Presentation	70	69	69	70	59	67.4	96.29
3	Language	50	49	46	50	42	47.4	94.80
4	Media	45	40	41	45	36	41.4	92.00
Amount		**225**	**216**	**213**	**225**	**189**	**213.6**	**Very Valid**
Percentage		**100**	**96**	**94.66**	**100**	**84**	**94.93**	

Based on the data contained in Table 5, all aspects of the e-module show a very valid category. After the e-module was declared feasible by the experts, individual trials were conducted (5 students) and small groups (10 students). The average individual readability test was 81.6 with a very practical category. In individual trials, students gave suggestions, namely increasing the size of the writing on

the e-module, and simplifying complex language so that it is easy to understand and the colors used are brighter. Meanwhile, the small group trial received a score of 83 with a very practical category. Learners give suggestions and comments in the form of corrections on words that are typed incorrectly. The suggestions and comments given at the validation and trial stages were used as evaluation material for the researcher to improve the products developed before proceeding to the implementation stage.

The next step is the implementation stage, namely using e-modules in chemistry learning in class X-E. The results of this stage are in the form of questionnaire data for the practicality test and pretest and posttest data for the effectiveness test which are then processed into research results. The implementation and data related to the practicality test and effectiveness test can be seen in the following Figure 6, 7, 8 and Table 6 & 7.

Figure 6. Teaching and Learning Process

Figure 7. Pretest Activity

Figure 8. Posttest Activity

Table 6. Recapitulation of Practicality Test

No.	Component	Score	Description
1	Readability	84.23	Very Practical
2	Student's Response	86.56	
3	Teacher Response	80	Practical
4	Teacher's Ability to Use E-modules	86.44	Very Practical
5	Learning Implementation	85.05	
Average		**84.46**	**Very Practical**

Table 7. Results of the Pretest and Posttest Critical Thinking Skills

No.	Test	Average	N-Gain
1	Pretest	21.74	81.15
2	Posttest	84.95	

Each stage of ADDIE conducts an evaluation stage. However, the evaluation was only conducted at the development stage, where researchers improved the e-module based on suggestions and comments from validators and during individual and small group trials. In addition, the evaluation was also conducted to complete the research and as a form of improvement so that the e-modules are ready for dissemination.

Discussion

Product Validity

The assessment given by the validator on the validity analysis concluded that the e-module received a very valid category. The content feasibility aspect received the highest score of 95.67, indicating that the e-module is by the 4 assessment indicators on the content feasibility aspect, while the media feasibility aspect received the lowest score compared to other aspects at 92.00. The low validation score given by the validator is because the media assessment is very crucial and affects appearance and attractiveness. This is relevant to the research of Fadhilah et al., (2020) the use of fonts, layouts, and illustrations can make teaching materials more interesting to read. Aspects of media assessment affect the clarity of the content presented and the proportionality of visuals, videos, texts, colors, and spacing by media standards (Luthfi et al., 2021).

Validation is needed because this is the process of assessing the feasibility of the product developed before the product is implemented in the learning process. E-module is learning material that contains explanations of specific knowledge, experiences, and practices, which are provided to help students understand certain material more easily. In the learning process, the use of teaching materials has a crucial role because it can help teachers achieve learning objectives, improve the quality of education, and make it easier for students to obtain knowledge and information related to the material being studied.

Product Practicality

The purpose of product practicality is to find out how easy the product is to use. This analysis uses data from readability questionnaires, student responses, teacher responses, observations of teachers' ability to use e-modules, and observations of learning implementation (Syukra & Andromeda, 2019). The purpose of the readability questionnaire is to find out how well students understand the e-modules developed and the results of the readability questionnaire are 88.11. The student and teacher response questionnaires aim to measure reactions to the developed e-modules in terms of interest, material, and language. Student response obtained a score of 86.56 and teacher response obtained a score of 80. Furthermore, the observation of the teacher's ability to use the e-module obtained a score of 86.44 and the observation of learning implementation obtained a score of 85.05.

Ease of use of e-modules is an important factor in determining whether e-modules can be useful and appropriate teaching materials as an alternative to learning that can encourage the learning process. Practicality data plays a role in determining the value of the products produced such as aspects of ease of use, efficiency of learning time, and the benefits of e-modules (Safitri & Sari, 2022; Syukra & Andromeda, 2019). Based on the average practicality obtained of 84.46, it was concluded that the e-module was suitable for use as the main supporting teaching material in the learning process. This is in line with the explanation given by Asmiyunda et al., (2018) that research and development products are considered practical if respondents, namely teachers, students, and observers, state that the product can theoretically be applied in the field, which means that the practicality assessment indicators have been met.

Product Effectiveness

This data analysis was conducted to test the critical thinking skills of X-E natural science students at Senior High School 5 Banjarmasin. The average obtained in the pretest was 21.74, indicating that students had difficulty in identifying questions and mastery of science knowledge that was not in-depth as stated in the test instrument, in addition, it is caused by the lack of practicing aspects of critical thinking skills in the learning process. The use of e-modules in learning causes an increase that can be seen in the average posttest, namely 84.95. This is in line with research of Kusasi et al., (2021) that the use of teaching materials used for direct student involvement will attract and increase the success of a learning process.

The interpretation of the effectiveness of N-Gain is in the effective category with a score of 81.15. Well-organized e-module materials equipped with additional information relevant to life can

influence N-Gain results. On the other hand, this e-module uses a problem-based learning model. The increase in critical thinking is certainly related to the learning model used so that it can improve the ability of students to explain and detail a problem. The learning process that invites students to solve authentic problems relevant to real life not only teaches them to receive information from the teacher, but also trains their ability to think critically, find solutions, process information, and communicate effectively during the learning process.

According to Syam (2020), with increasing age and the development of the social environment, each individual is often faced with increasingly complicated and complex problems, to face this situation and survive a person must have the ability to think critically and creatively. The cognitive process that involves consideration to analyze and evaluate is called critical thinking (Saputra et al., 2019). In the learning process, critical thinking plays an important role because it helps students build knowledge and cognitive reasoning skills and helps answer questions about how and why a concept is used (Ayun et al., 2020; Juliyantika & Batubara, 2022).

CONCLUSION

The results of the research and discussion of the e-module of basic laws of chemistry based on problem-based learning to improve critical thinking skills show that the e-module is very valid with a validity score of 94.93, very practical with a practicality score of 84.46, an effective with an N-Gain score of 81.15. Suggestions for future researchers are that the developed e-modules can be accessed without using the internet and the testing of the developed products can be more than one school.

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Digital skills assessment in blended learning settings in mathematics and physics education programs

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ABSTRACT

Digitally savvy human resources are becoming more necessary. Through a survey, this research assesses students' digital skills after implementing blended learning. A total of 143 mathematics and physics teacher students provided their self-assessments of 25 indicators of digital skills. The findings show that around 50% of students can adapt to technology, and 61% rate it well for their creative ability in dealing with ideas. However, there is potential for improvement in problem-solving skills. In cultural awareness, more than 90% of students demonstrated respect for other cultures, although around 23% rated it sufficient for cultural understanding. Student ethics in using technology were high, with more than 85% stating they had good abilities. Assessments of core and contextual digital skills show a tendency for students to give higher ratings to core skills, but assessment variations are pretty significant. The mean scores and standard deviations for both skill categories indicate a level of variation that is noteworthy. This study provides in-depth insight into students' digital skills assessment, identifies potential areas for further development, and highlights the need for increased cultural awareness among students. This research recommends further investigation to determine the types of digital skills students gain from the wider use of the Internet and how well these skills fit the needs of the digital age.

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INTRODUCTION

The development of information technology in Indonesia, as reflected by the National Statistics Agency's (BPS) survey between 2019 and 2022, shows significant trends in Internet use among students at various levels of education. The survey results highlighted quite a marked increase, with the percentage of students using the Internet increasing from around 53% to more than 76%. This increase is in line with the surge in student cell phone use. The National Statistics Agency's survey findings create a picture of a significant transformation in students' behavior as digital learners, who are increasingly allocating more time to use technology flexibly (Tiba & Condy, 2021). This phenomenon highlights the need for a deep understanding of the characteristics of digital learners. Digital learners are individuals who actively use technology to obtain, process, and interact with information in various learning contexts (Tiba & Condy, 2021). This generation can adapt quickly to new technologies (Alibrahim, 2024). The dominance of digital technology in Industry 4.0 necessitates enhanced technological proficiency, particularly for future generations, emphasizing the

importance of educational reforms that not only transfer knowledge but also focus on imparting the skills required to meet the challenges of this era (Ekantiningsih & Sukirman, 2023).

Along with this change, the need for human resources who have digital skills is increasing. Laar et al., (2017) defined digital skills as the capacity for lifelong learning, supporting higher-level thinking, and mastering technology to accomplish tasks. Digital skills are applying specific knowledge and talents that can be applied and measured in digital use (Iordache et al., 2017). The educational context also reflects the importance of digital skills for facing challenges in this digital era. Laar et al., (2017) emphasize that developing digital skills is integral to the teaching and learning process. It aims to ensure that students not only master these skills in the classroom environment but can also apply them in life and work in the ever-growing digital era. During the pandemic COVID-19, teachers enhanced their technology and teaching skills, demonstrating their students' high digital skills and ability to learn independently, demonstrating their quick adaptability to new technologies (Alibrahim, 2024). Thus, teachers are expected to be able to use technology to create learning to facilitate the characteristics of digital learners by training their digital skills.

The educational context also reflects the importance of digital skills as provisions for facing challenges in this digital era. Teachers, serving as facilitators in education, should ensure students' learning convenience through the effective use of innovative learning media, particularly ICT, to stimulate optimal student potential (Ekantiningsih & Sukirman, 2023). The UNESCO-UNEVOC study highlights the need for differentiated support for teachers to effectively use digital tools and services, including building digital skills, knowledge of new technologies, and developing competencies in new pedagogical approaches (Subrahmanyam, 2022). Laar et al., (2017) emphasize that developing digital skills is integral to the teaching and learning process. It aims to ensure that students not only master these skills in the classroom environment but can also apply them in life and work in the ever-growing digital era. Thus, teachers are expected to be able to use technology to create learning to facilitate the characteristics of digital learners and train students' digital skills.

Several empirical studies have described the ability of prospective teachers or teachers in Indonesia to use technology. For example, survey results of 208 prospective teachers in Jakarta found that although the perception of self-confidence in using technology was positive, integrating technology, pedagogy, and teaching materials still needed improvement (Diamah et al., 2023). A study in 2022 on 901 Indonesian teachers found that effective learning can be achieved through technology if teachers have high confidence in using it in classrooms (Prasetiyo et al., 2022). Diamah et al., (2023) suggest that prospective teachers still need to improve their digital skills in lectures. For example, by applying project-based learning methods to train collaboration or research-based learning to increase creativity (Lavi et al., 2021). Therefore, prospective teachers must be equipped with knowledge and trained in skills using digital technology for learning.

The first step before designing a skills improvement program for prospective teachers is identifying their initial skills. Many studies have reviewed hundreds or thousands of scientific articles discussing digital skills and formulated relevant dimensions, factors, and indicators. The digital skills framework proposed groups digital skills based on core and contextual (Laar et al., 2017). Core digital skills include technical, information management, communication, collaboration, creativity, critical thinking, and problem-solving. Contextual digital skills include ethical awareness, cultural awareness, flexibility, self-direction, and lifelong learning. This research aims to analyze the digital skills of prospective mathematics and physics teachers based on core and contextual skills. Core skills provide a foundation for performing specific tasks, while contextual skills provide adaptability and flexibility to apply those core skills in different contexts (Laar et al., 2017).

Regarding technological experiences, Tiba & Condy (2021) reported that teachers' TPACK (Technology Pedagogy and Content Knowledge) assessments improved when they were modeled to integrate technology, pedagogy, and material knowledge throughout their prospective teacher education. TPACK covers aspects of digital skills in the context of teaching and learning, while digital skills are more general and involve the ability to use technology in various life contexts. TPACK can be considered as part of digital skills that are more specific to the world of education. Teacher education institutions should integrate digital skills with practical applications and review assessment design to deepen preservice Teachers' TPACK development (Bothe, 2023). Demographic, socioeconomic, age, gender, education level, personality, psychology, and prior

technological experience all substantially impact technical aspects, information management, problem-solving, and communication (Laar et al., 2020). It shows, that more research is required to determine how core and contextual skills relate.

On the other hand, the basic skills needed for digital skills include using the Internet and online content, for example, through e-learning (Laar et al., 2020). Tiba & Condy (2021) stated that knowledgeable and skilled teachers will use technology effectively to constructively change the teaching and learning process so that students also get used to using technology for good purposes. Teachers at all levels need to be taught digital literacy skills using a variety of approaches to deal with the realities of technology in the classroom (Zayas & Rofi'ah, 2022). Therefore, prospective teachers must have the skills to select, design, create, modify, and use Internet-based technology and digital content for classroom learning. In other words, getting used to digital technology needs to be planned systematically in learning.

Laar et al., (2020) stated that prospective teachers' readiness to use technology during teaching is influenced by three factors: projects and workshops on technology, resources, and modeling the use of technology by lecturers and supervising teachers in schools. Digital skills are improved through technology in learning, where students develop thinking skills, creativity, practice, and participate in project assignments (Pipatjumroenkul et al., 2019). Integrating digital literacy skills into learning can improve students' functional skills, creativity, collaboration, communication, critical thinking, cultural and social understanding, and cyber security awareness (Webb & Layton, 2023). Introducing digital tools and technology-assisted pedagogical strategies integrated into teacher or prospective teacher education programs is one of the keys to success in increasing digital skills (Zayas & Rofi'ah, 2022).

Combining online and offline learning, namely blended learning, can expand communication channels between students and between teachers and students, learning flexibility, personalization, the development of independent learning, and cost efficiency (Müller & Mildenberger, 2021; Smith & Hill, 2019). The development of blended learning aims to combine the best characteristics of face-to-face and online learning to increase active participation and learning independence (Khoiroh et al., 2017). Teachers integrate online learning as part of blended learning and use technology for a variety of educational purposes, such as providing additional lessons, completing homework, and communicating with students and parents (Alibrahim, 2024). Depending on each institution's capacity, choosing a blended learning model that suits its demands based on facilities, the financial situation, the subject and curriculum, and more is imperative (Tong et al., 2022).

The blended pedagogy approach improved digital competencies among the teacher trainees, particularly in areas such as internet navigation, mobile Internet operation, internet-based search engines, and formal internet skills (Buluma & Walimbwa, 2021). Implementing blended learning provides students with the experience of opening and downloading modules or learning materials whenever needed (Kusyanti, 2022). Blended learning gives students the readiness for in-person interactions and allows teachers to assess learning outcomes and decide on the best course of action for future learning activities more rapidly (Yuricha & Phan, 2023). Thus, the blended learning approach makes a positive contribution to improving communication, learning flexibility, and student independence while strengthening teachers' digital competence. In addition to improving knowledge, abilities, and attitudes, blended learning also has the positive impact of reducing the expense of courses and training (Abuejheisheh et al., 2023).

The advantages of blended learning are relevant to the digital skills that prospective teachers are expected to have in the era of digital technology. The knowledge, skills, and competencies required for teaching in technology-enhanced environments differ from those for face-to-face teaching, especially when asynchronous delivery is used (Alibrahim, 2024). However, there is a gap in understanding the specific digital skills and competencies students develop or lack during this increased Internet use, especially in blended learning settings, and how these align with the digital skills required in teaching. Meanwhile, the value of including digital literacy skills in teacher preparation is acknowledged, but little is known about how well various methods work to foster these abilities. It is necessary to research to identify the digital skills enhanced by blended learning and their alignment with the expectations of the digital era in education for preservice teachers. This

study addresses the digital skills assessment method for student teachers through blended learning, offering recommendations for improvement based on assessment results. It contributes to the development of effective teacher training curricula and learning strategies for preparing teachers for the digital demands of modern education.

METHOD

Research Design

This study is descriptive quantitative research using a survey method that aims to analyze the digital skills of prospective mathematics and physics teacher students in blended learning. The blended learning environment provides conditions for exploring sufficient essential experience and skills for using technology in learning. Face-to-face learning is carried out in the lecture hall, while online learning is carried out via http://elearning.unib.ac.id, which was developed using Moodle as a Web-based Learning Management System (LMS). Moodle allows the construction of online teaching environments with teaching materials and the creation of activities, such as quizzes, interactions during continuous lectures, and tests for assessment (Ifinedo et al., 2018). This research uses a descriptive quantitative approach because it allows systematic data collection through survey instruments, and then analyzed quantitatively to an explanation of students' digital skills (Bhat et al., 2024).

Sampling Technique

The sampling technique used was purposive sampling, with the criteria of prospective mathematics and physics teacher students who had completed blended learning-based lectures. This technique was chosen because the respondents were seen as having characteristics that were relevant to the research objectives, namely to evaluate their digital skills in the context of technology-based learning (Bhat et al., 2024). Data in survey research is obtained from several individuals by asking questions and then using their answers to provide certain information (Lukitasari et al., 2022). The research respondents were 143 prospective mathematics and physics teacher students at a state university in Sumatera, aged 17–21 years. The proportion of respondents based on gender was 81.1% women and 18.9% men.

Data Collection

Data were collected using an online questionnaire distributed via Google Forms. The questionnaire instrument was adapted from the (Laar et al., 2017) framework, which includes 25 digital skill indicators divided into all seven core skills and three contextual skills (ethical awareness, cultural awareness, and flexibility). Self-direction and lifelong learning were not measured in this study because they require measurement more than one time through observation and interviews, which involve qualitative aspects that are difficult to convert into quantitative data that can be measured. The assessment was carried out using a three-point Likert scale: Good (3), Fair (2), and Poor (1). Before participating in the study, all respondents were provided with detailed information about the research objectives, procedures, and their rights as participants. An informed consent form outlining their voluntary participation was presented, and their responses would remain anonymous and confidential. Only those who fully understood and willingly agreed to the terms of participation were allowed to proceed with the self-assessment questionnaire. Table 1 consists of the dimensions and indicators of digital skills used in the research.

Table 1. Dimension and Indicators of Digital Skills

No.	Categories	Dimensions	Indicators
1.	Core Digital Skills (Y)	Technical (TC)	TC1. Able to use Mobile Devices and Applications to Complete Practical Tasks. TC2. Able to use the Features in E-learning to Complete Assignments.

No.	Categories	Dimensions	Indicators
		Information management (IM)	IM1: Able to use technology to efficiently search for information when making the most suitable decisions for specific tasks.
			IM2: Able to use technology to select information efficiently when making decisions for specific tasks.
			IM3: Able to use Technology to Organize Information Efficiently when Making the most Suitable Decisions for Specific Tasks.
		Communication (CM)	CM1. Able to use Technology to Send Information to Others.
			CM2. Able to use Technology to Ensure that the Meaning of Information is Expressed Effectively.
		Collaboration (CL)	CL1. Able to use Technology to Develop Social Networks in Teams to Exchange Information.
			CL2. Able to use Technology to Work in Teams to Exchange Information.
			CL3. Able to use Technology to Negotiate Deals with Mutual Respect for a Common Goal.
			CL4. Able to use Technology to Make Decisions with Mutual Respect to a Common Goal.
		Creativity (CR)	CR1. Able To Use Technology To Generate New Ideas Into Something New.
			CR2. Able to use Technology to Treat Current Ideas in a New Way Into Something New.
		Critical Thinking (CT)	CT1. Able to use Technology to Make Decisions based on Acquired Information.
			CT2. Able to use Technology to Make Choices based on Acquired Information.
			CT3. Able to use Technology to Communicate Logically to Support a Statement.
		Problem Solving (PS)	PS1. Able to use Technology to Cognitively Understand Problem Situations to Find Solutions.
2.	Contextual Digital Skills (X)	Ethical Awareness (EA)	EA1. Able to Behave Socially Responsibly when using Technology.
			EA2. Able to Demonstrate Awareness when using Technology.
			EA3. Able to Behave Ethically by Applicable Laws when using Technology.
		Cultural Awareness (CA)	CA1. Able to Demonstrate Cultural Understanding when using Technology.
			CA2. Able to Respect Other Cultures when using Technology.
		Flexibility (FL)	FL1. Able to Adjust One's Thinking to Change the Technological Environment.
			FL2. Able to Adjust One's Attitude to Change the Technological Environment.
			FL3. Able to Adjust One's Behavior to Change the Technological Environment.

(Laar et al., 2017)

Data Analysis

The data collected were analyzed using descriptive statistics to assess students' digital skills in both core and contextual skill dimensions. The results of the data processing are presented through charts and tables, which illustrate the distribution of digital skills across each indicator and allow for a comparison of students' skills in core and contextual skills.

RESULTS AND DISCUSSION

Results

Data is collected at the end of lectures that apply blended learning. Students are asked to assess their digital skills based on good, fair, or poor criteria for 25 indicators. This research compares the value of individual digital skills between core and contextual skills. All indicator values for each skill category are given a value in the range 1–3. To determine performance levels, the average scores for each dimension were categorized as good (2.35–3.00), fair (1.68–2.34), and poor (1.00–1.67). The individual assessment results are visualized in the following scatter plot in Figure 1.

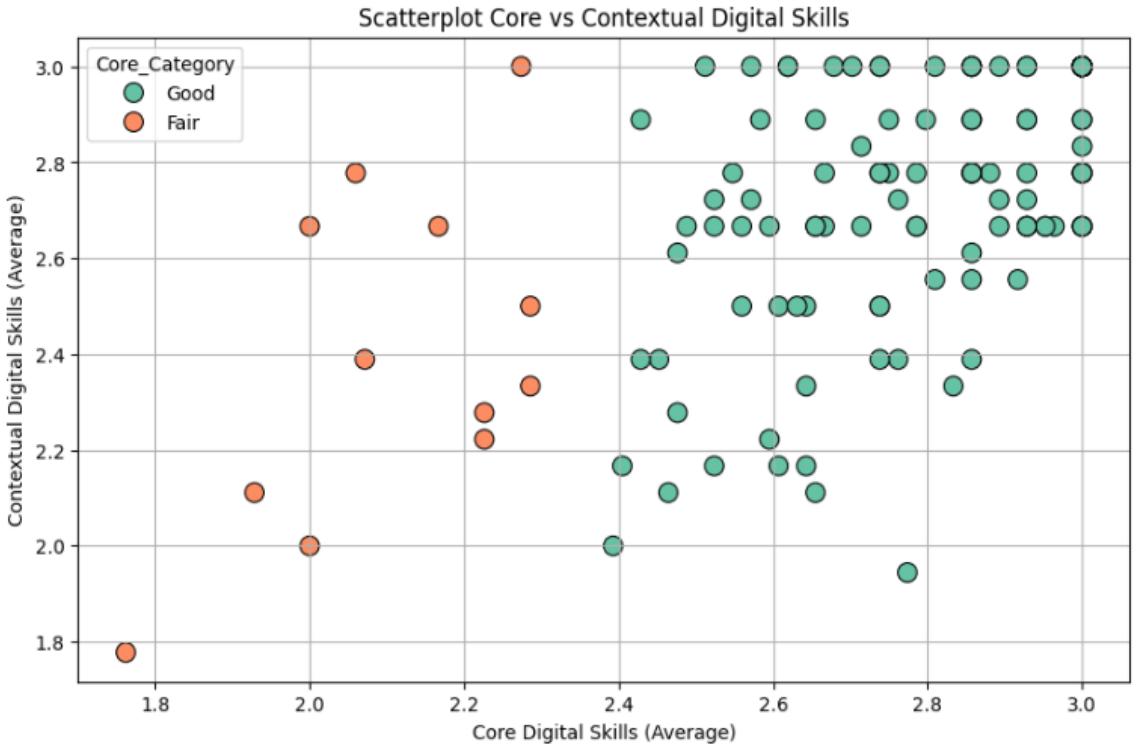

Figure 1. Scatter Plot of Individual Assessments Between Core and Contextual Digital Skills

The scatterplot analysis in Figure 1 illustrates the relationship between core and contextual digital skills among participants. Each data point represents an individual, with their average core digital skills score plotted on the x-axis and their average contextual digital skills score on the y-axis. The color-coded data points, distinguishing individuals categorized as "good" or "fair," reveal no significant differences in the relationship between the two skill sets across these categories.

Most data points are concentrated in the upper-right quadrant, indicating that a majority of individuals demonstrate strong performance in both skill categories. Out of 143 prospective teachers, 12 individuals were categorized as having fair core digital skills, and among them, only 5 had fair contextual digital skills. The remaining 91.61% (131 out of 143) of participants demonstrated good core digital skills, although 10 individuals in this group were categorized as having fair contextual digital skills. These results indicate a higher proportion of participants achieving good performance in core skills compared to contextual skills. However, notable variations exist, as some individuals with high core digital skills scores exhibit relatively lower contextual skills scores, and vice versa. This highlights diversity in skill profiles across the sample.

These findings suggest that core and contextual digital skills are interrelated, and strengthening one dimension may support improvements in the other. This insight underlines the importance of integrating both skill sets in digital skill enhancement programs to ensure comprehensive digital literacy development. Figure 2 below shows the percentage of each dimension.

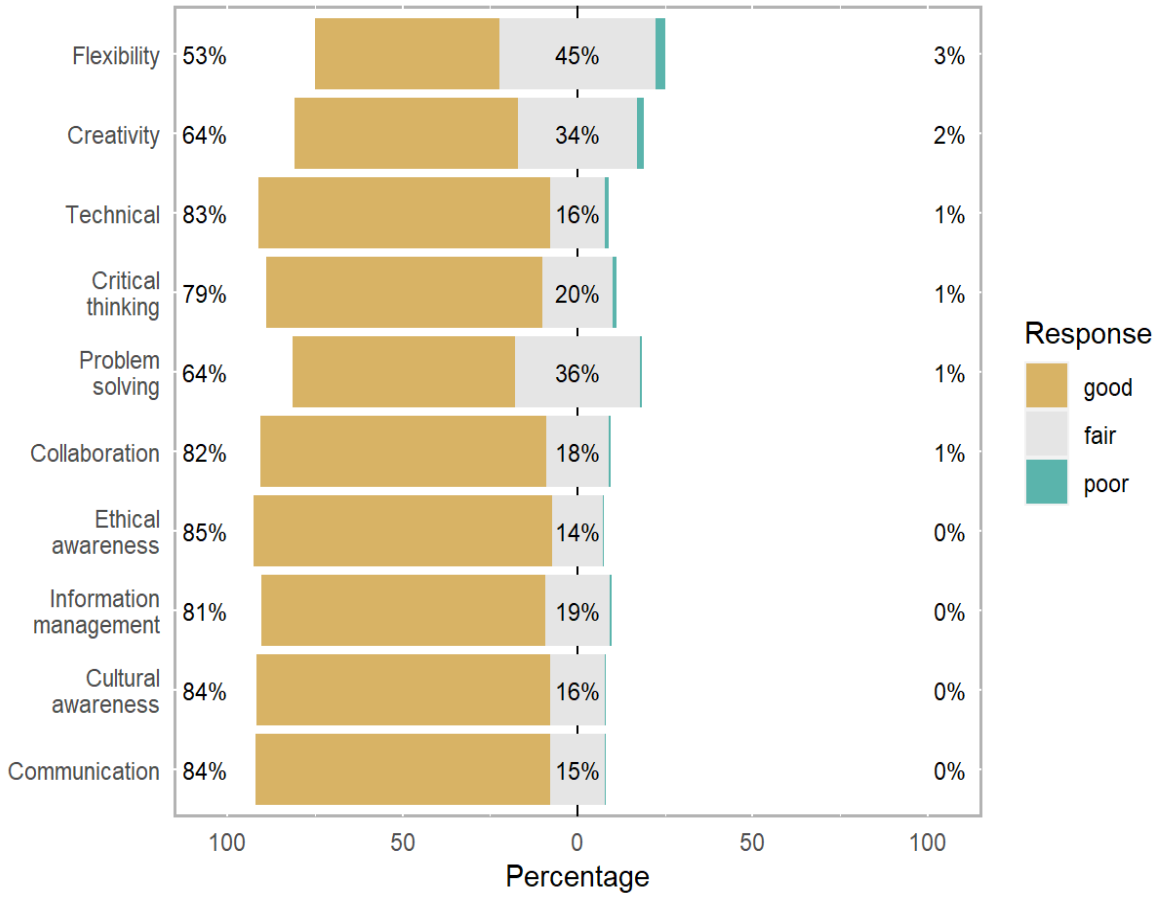

Figure 2. Average Percentage of Digital Skills Dimension Assessments

The response results show that most students believe they have a good core (around 78%) and contextual (around 73%) digital skills. An interesting finding from this research is the cultural awareness dimension. More than 90% of students stated that they can respect other cultures when using technology. However, there are still around 23% who consider it sufficient to demonstrate cultural understanding when using technology. Therefore, there is potential to increase further cultural awareness of the use of technology among students, although most of them already have a strong foundation in this dimension.

On the other hand, in the ethical awareness dimension, more than 85% of students stated they had good abilities. Students can behave socially responsibly, demonstrate awareness, and be ethical by the law when using technology. This positive value shows that they have a strong moral foundation and commitment to using technology. It provides a solid basis for forming professionalism and integrity in the context of future use of technology.

Meanwhile, for technical, collaborative, ethical, information management, cultural, and communication abilities, more than 81% of students received good ratings. However, if we look in detail at the dimensions of creativity, problem-solving, and flexibility, less than 70% of students have good skills. Around 34 – 45% of students rated themselves in the adequate category in these three dimensions. Thus, efforts are still needed to increase skills in creativity, problem-solving, and flexibility among students.

This study also identifies in greater depth the specific digital skill indicators that require more attention. By analyzing the distribution of scores across the Good, Fair, and Poor categories for each indicator, it becomes evident where there are opportunities for improvement. Figure 3 illustrates this comparison, providing a detailed percentage breakdown for each indicator.

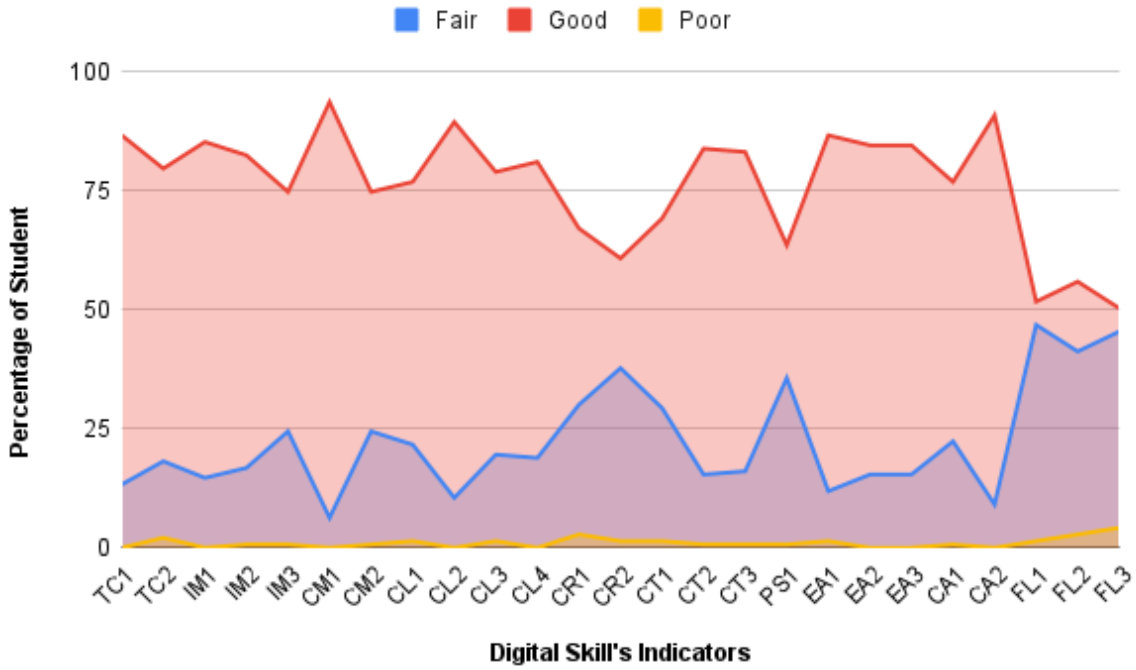

Figure 3. Distribution of Student Ratings for Each Digital Skill Indicator

As shown in Figure 3, certain indicators in both Core Digital Skills and Contextual Digital Skills have potential for improvement. For instance, in the Technical (TC) dimension, TC1 (the ability to use mobile devices and applications to complete practical tasks) stands out with a high proportion of participants (86.71%) falling in the good category. However, TC2 (the ability to use e-learning features effectively to complete assignments) shows a slightly lower performance, with 79.72% in the good category and a noticeable percentage (18.18%) in the Fair category. This discrepancy suggests that while most participants are adept at using mobile devices and applications, there is a gap in the mastery of e-learning platforms that should be addressed to improve the overall learning experience. Technical digital skills, which include handling software, social media channels, and the internet for task completion, as well as basic digital problem-solving, are essential for everyday tasks across professions and can significantly enhance productivity in educational settings (Bouwmans et al., 2024).

In the Information Management (IM) dimension, indicators such as IM1 (the ability to use technology to efficiently search for information) and IM2 (the ability to select information efficiently) show strong performance, with over 85% of participants scoring in the good category. However, IM3 (the ability to organize information efficiently) exhibits a more diverse distribution, with a larger proportion of participants (24.48%) categorized as Fair. This highlights a potential area for growth, suggesting that while participants are capable of searching and selecting information, organizing it effectively remains a challenge.

In the Creativity (CR) dimension, the indicator CR1 (using technology to generate new ideas) receives a favorable score, with 81.12% in the good category. However, CR2 (using technology to treat existing ideas in a new way) presents a notable gap, as 30.07% of participants are rated in the Fair category. This indicates that while participants are generally good at generating new ideas, their ability to apply creative processes to existing ideas and produce innovative results is an area that needs more attention.

Within the Problem Solving (PS) dimension, PS1 (using technology to understand problem situations and find solutions) reflects a mixed performance. While 63.64% of participants are rated as Good, a significant proportion (35.66%) fall into the Fair category. This suggests that although many participants possess a foundational understanding of problem-solving with technology, further support and skill development are necessary to enhance their ability to apply technology effectively in more complex problem-solving contexts.

In the Contextual Digital Skills, the Flexibility (FL) dimension shows mixed results. While FL1 (adjusting thinking to changes in the technological environment) is strong, with 90.91% in the good category, the indicators FL2 (adjusting attitudes) and FL3 (adjusting behavior) show a more concerning trend, with 22.38% of participants in the Fair category for both indicators. This suggests that while students are capable of adjusting their thought processes to new technological environments, they struggle with adapting their attitudes and behaviors to these changes, which could hinder their full integration and effectiveness in dynamic technological settings.

Overall, this analysis reveals that while participants generally perform well in most dimensions, several areas—particularly in Problem Solving, Creativity, and Flexibility—require additional focus and development. These findings suggest the need for targeted interventions to enhance specific digital competencies, ensuring that participants are not only proficient in using technology but also able to apply it in innovative, adaptable, and effective ways.

Discussion

This study highlights various aspects relevant to students' digital skills in a blended learning context. The previous research reveals that in a blended learning context, core skills (e.g., basic digital literacy) and contextual skills (e.g., application in specific learning environments) are interdependent, influencing overall digital competency (Satar et al., 2024). The study reveals that core digital skills, such as technical, information management, communication, and critical thinking, are rated higher than contextual skills like ethical awareness and cultural awareness. Interestingly, only 5 out of 12 students with fair core skills demonstrated fair contextual digital skills, suggesting that students with fair core skills often face challenges in contextual skills. These variations in assessment indicate differences in perception among students, highlighting the complexity of assessing digital skills in a blended learning context.

This research found that students rated it as fair for problem-solving skills but rated it as good for critical thinking. It reflects students' ability to use technology for logical decision-making and effective communication. Critical thinking involves analyzing information, evaluating arguments, and making reasoned decisions. It is essential for effective communication and is increasingly integrated into educational frameworks to prepare students for the workforce (Thornhill-Miller et al., 2023). In contrast, problem-solving requires deeper cognitive engagement, such as understanding complex situations and formulating appropriate solutions. These findings are consistent with prior research indicating that critical thinking involves more technical applications of technology, while problem-solving requires deeper cognitive engagement (Laar et al., 2017; Saekawati & Nasrudin, 2021). While critical thinking and problem-solving are often viewed as separate skills, they are interrelated. In the research's context, blended learning allows students to deepen their critical thinking and problem-solving skills through combining e-learning and face-to-face courses. It is often linked to higher-order thinking skills, which can be fostered through active learning strategies such as problem-based learning and collaboration-driven approaches (Patiño et al., 2023).

The student assessment for critical thinking aligns with the assessment for the collaboration dimension, which is considered good. It is related to student activities in collaborative group work, providing opportunities to collaborate in planning, implementing, negotiating, and evaluating when solving problems (Saekawati & Nasrudin, 2021). Problem-solving skills are considered essential abilities that involve analyzing complex situations, identifying challenges, and developing practical solutions. Blended learning facilitates students receiving material explanations from teachers and using e-learning, which can be accessed anywhere and at any time (Sari et al., 2022). When it comes to problem-solving, students must have access to various information, including material that can be quickly found online. However, it is also essential to consider the suitability of the data selection for the discussed topic (Shalihah et al., 2019).

Problem-solving skills are essential for resolving problems, making informed decisions, and adapting to changing circumstances. As done by Sari et al., (2022), five crucial elements of blended learning, namely live events, online content, collaboration, evaluation, and reference materials, are used to combine the concepts of blended learning and project-based learning with building knowledge and skills in problem-solving. In this context, Bothe (2023) emphasizes integrating digital

skills development in teacher education to equip pre-service teachers with the knowledge and skills acquired during school placements, enabling them to effectively solve problems and adapt to technology-rich educational environments. This integration guarantees that pre-service instructors are more prepared to solve difficulties and adjust to technologically advanced educational contexts.

On the other hand, discussion forums in e-learning allow students to collaborate and share information and understanding to solve the problems they are facing. Social interaction in e-learning expands discussion opportunities that have been carried out in the classroom (Saekawati & Nasrudin, 2021). Data from student responses in e-learning reflects their ability to use technology to understand problem situations and find solutions cognitively. This analysis shows that although students assess problem-solving skills as sufficient, some components have been facilitated in blended learning. Thus, it is necessary to design learning activities in blended learning to explore more challenging cognitive understanding of situations.

Digital flexibility skills refer to the ability to adapt and adjust to changes in the digital context, especially in the era of continuously developing information and communication technology. Theoretically, blended learning allows students to learn at their own pace and access course materials online, resulting in a more flexible and personalized learning experience. Blended learning allows students to manage learning independently through materials, discussion forums, and feedback freely available in e-learning (Khoiroh et al., 2017). However, this research shows that, in general, students as prospective teachers still need to train their flexibility to move between platforms, adapt to new technology, and overcome challenges that arise with changes in the digital environment.

The study's results by Laar et al., (2020) show that problem-solving and creativity skills are significantly determined by experience and flexibility in using technology. Further improvement of flexibility skills in using technology for problem-solving and creativity can be done through blended learning. Blended learning requires students to be active, learn to focus, and explore information from various sources, especially the Internet (Shalihah et al., 2019). The previous study demonstrates that a blended learning support system, including learning planning, content, activities, and assessments, can significantly enhance the digital literacy of prospective teachers, proving to be a practical and effective solution (Rahmi et al., 2024). This research shows a blended learning approach in developing the digital flexibility skills of student teachers, enabling them to be better prepared to face changes and demands in an ever-evolving digital environment.

One of the e-learning features that can be utilized in blended learning is data log activities. Log data analysis can reveal students' engagement patterns, indicating their consistency and discipline in accessing and submitting online assignments (Zare et al., 2023). Log data analysis on Moodle can reveal active student times, engagement patterns, and peak activity periods through the examination of event logs (Rotelli & Monreale, 2023). If the activity log shows a high participation level, this indicates active engagement in learning. Group discussion strategies, collaborative projects, problem-solving activities, and interactive online modules carried out in e-learning to complement face-to-face learning effectively improve digital skills and competencies (Buluma & Walimbwa, 2021). The analysis of log activities is relevant to important aspects of blended learning. Kusyanti (2022) mentions the critical aspects of blended learning, including a combination of technology, pedagogy, and chronology (synchronous/asynchronous).

Log data has a chronology feature that shows the time and frequency of e-learning access by students. Log data analysis can reveal patterns in student activity frequency, such as peak times for reading materials, participating in forums, or completing quizzes (Darmawan, 2024). This information helps lecturers understand students' preferred time patterns in accessing material or interacting with assignments. If online assignments or exams exist, log data can show how often students access and submit assignments. It can be an indicator of consistency and level of discipline. Additionally, by analyzing log data, institutions can design personalized learning pathways, ensuring students receive support tailored to their individual engagement and performance trends (Kim & Park, 2022).

Apart from that, from a pedagogical aspect, through log data, lecturers can see the materials or modules that are most frequently accessed by students, making it helpful in assessing the level of interest or difficulty in specific courses. In this research, e-learning is also equipped with online quizzes, announcements, and links. Access log data to these features is used to understand how

students utilize various learning features (Darmawan, 2024). Increasing student participation in e-learning increases digital skills (Pipatjumroenkul et al., 2019). Blended learning enhances students' and teachers' technology skills, teaching strategies, and personal development by integrating interactive applications and enhancing digital skills, while also promoting independent learning (Alibrahim, 2024). This research shows that the application of blended learning in lectures has a generally positive impact on assessing students' digital skills, both core and contextual skills, as prospective teachers.

CONCLUSION

The research findings highlight the need for increased focus on specific aspects of learning to improve digital skills. Research shows differences in students' assessments of core and contextual digital skills. Creativity is recognized as a core skill in the digital era. However, assessments show that students feel less able to be creative. Even though problem-solving is considered adequate, critical thinking and collaboration skills are excellent. On the other hand, although theoretically, blended learning facilitates flexibility in learning, this research shows that students need to exercise their flexibility in switching between platforms and adapting to new technology. Most students rated higher for core skills, while variations in ratings reflected differences in perceptions among students. It emphasizes the complexity of assessing digital skills in a blended learning context.

Implementing blended learning generally positively impacts assessing students' digital skills. Technology integration, online quizzes, announcements, and other features in e-learning help increase participation and digital skills. E-learning activity log data helps understand students' participation, preference time patterns, interests or difficulties, and level of discipline. Log data analysis can provide valuable insights for lecturers to optimize learning design. This research opens up space to formulate implications and recommendations, including further development efforts on skills that need to be improved, strategies to increase cultural awareness, and a better understanding of variations in perceptions among students. Thus, this study provides a valuable contribution to understanding students' digital skills in blended learning environments, providing a foundation for further discussion and development actions based on research findings. Further research is needed to identify the types of digital skills students acquire through increased Internet use and how these skills align with the demands of the digital era. While various studies define digital skills, it is also necessary for future research to delve into the nuanced influence of demographic and socioeconomic factors on specific digital skills, providing a more detailed understanding of tailored interventions.

The research suggests that teacher education programs should incorporate activities that foster creativity and flexibility, such as project-based learning and problem-solving workshops, to enhance student engagement and skill development. Enhanced e-learning features, such as real-time feedback and adaptive learning modules, can also enhance learning experiences. Regular analysis of e-learning activity logs can help identify areas for improvement. Blended learning programs should capitalize on students' strong ethical and cultural competencies by incorporating cross-cultural collaboration projects. Future research should investigate digital skill trajectory, demographic and socioeconomic influences, and technology-specific skill development. Comparative analyses between traditional, fully online, and blended learning environments are essential for fostering diverse digital skills. Long-term research should investigate the career readiness of students equipped with enhanced digital skills.

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Effect of VR simulations on MPA level & breath control of voice major students

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ABSTRACT

A form of art that is created through a performance by one or an ensemble of performers, shown in front of an audience is called the performing arts. Despite having its appeal, performing in front of many people can lead to "performance anxiety". Performance anxiety is especially very concerning for singers and voice students. This can lead to diminished performance quality and impair the control of their vocal technique, with the most affected one being their breath control, which is considered one of the most crucial techniques in singing. A survey conducted on voice students of Pelita Harapan University Conservatory of Music has found this as a phenomenon that's been experienced by students, noticed by the voice lecturers, but yet to be effectively addressed. Previously, the use of VR simulations has been found effective in helping treat and decrease the symptoms and occurrence of social anxiety, which includes performance anxiety. However, a very limited amount of research has been done on the impact of VR on music-related performance anxiety (MPA), and even less specifically on singing performances. Through a mixed-method approach and by adopting the within-subject research design, this study aims to study the effects of VR simulation implementation on nineteen voice major students of Pelita Harapan University Conservatory of Music's MPA level and breath control. Results found that the method was effective in treating the MPA symptoms and did improve the students' breath control but was not conducted long or frequently enough to take a long-term or permanent result.

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INTRODUCTION

One of the most popular and oldest forms of art is the performing arts, which can be defined as a live event or activity by one or a group of artists or performers (Bezrucka, 2011). This also means that the artist would showcase their art and performances in front of an audience. One of those performing arts branches is a musical performance, which includes singing. Fundamentally, the human voice is a wind instrument, consisting of the lungs working to provide the air, the vocal cords creating vibrations that create the sound, and the mouth, nose, and upper throat as the chamber that creates resonation in our voices (Devi, 2021). In the world of vocal pedagogy, vocal technique is something that is always elaborated, as it is a very crucial part of building a healthy and long singing career (Rosine, 2018), as well as training the singers on how to make a pleasant sound and delivering

the message of the song itself. Thus, although it is based on physical principles, singers and voice students must have an understanding and be able to feel exactly what happens in their bodies when they are singing.

Summarizing from vocal pedagogy textbooks and scientific journals, vocal technique is divided into four aspects (Peckham, 2010; Christy & Paton, 2006; Agheana, 2022; Kovalsky, 2021). First, proper breath control starts with holding the right posture when we sing, as this opens up our bodies and allows a good amount of air to come in and out and allows us to be more relaxed when singing. The right singing posture happens when vertically, the whole body, from head to toe, is in one straight alignment, steady but not tense, balanced, and flexible. The chest is in an upright and tall position, but not forced. The knees are relaxed, and the feet are opened shoulder-wide to provide the singer with a good balance. Once a singer is in the correct posture, to execute the correct breath control technique he/she can inhale through the nose and/or mouth whilst expanding the ribs and abdominal muscle around the waist, allowing the diaphragm to contract. This singer should then sustain this contracting abdominal and diaphragm position while singing is taking place, and finally, once the sentence or phrase is done, the singer can then exhale and release all contractions happening in the abdominal part of the body. This cycle is to be repeated all over again in every sentence or phrase the singer is singing (Devi, 2021; Peckham, 2010). Second, the voice production aspect is an essential process of creating an efficient, varied, balanced, and expressive sound. The right voice production should create a steady and clear sound, stay on the right pitch, and be flexible, as well as help the singer control the volume and dynamics when they're singing (Christy & Paton, 2006). Third, the use of vocal resonance impacts the way we sound and the color of our voices. Fourth, the articulation. The articulator organs in our bodies consist of our mouth, teeth, and tongue, as well as our soft and hard palates. These organs give us the ability to form words or lyrics clearly, hence making it a very important part of singing due to their impact on the song delivery and ability to be able to be perceived and understood well by the audience.

Other than its benefit towards the singing itself, the execution of a good vocal technique, especially breath control, can be a tool for relaxation during the performance itself. The constant cycles of inhaling and exhaling help relax our joints and muscles, regulate our thoughts, and give us a sense of calmness and consistency. With all this in mind, it is crucial to make sure that this breathing technique is well integrated with the other singing techniques. It is also very important to note the fact that each singer is different and that there is always the possibility that different ages, genders, and body types might also bring slight differences in the way we conduct this breathing technique in singing. In other words, what works for one singer might not work for the other (Watson, 2014).

Despite having the skill and ability needed to sing well and execute the performance, more often than not, singers and performers would experience something called "performance anxiety". Performance anxiety falls under the umbrella of social anxiety disorder (SAD) and goes beyond shyness or feelings of unease. Performance anxiety happens when someone experiences persistent and extreme distress before or during a performance or a public event, with the fear of failing the performance or other disastrous outcomes (Barbeau & Mantie, 2018). Furthermore, performance anxiety usually happens when unfamiliar people are involved, such as in work interviews, tests, auditions, debates, or during an art performance, like music. Despite often being perceived as something negative, the feeling of anxiousness is something mankind needs in their lives, as this can help us respond and prepare ourselves better for the possibility of threats or danger (Saleh, 2019). However, when the level of response someone makes is not appropriate to the actual threat, this can cause problems. When this happens anxiety can very much appear without a tangible presence of the threat and can be very hard to address or control. Simply put, when it is in the right and appropriate amount, anxiety is beneficial, but when it is excessive, persistent, uncontrolled, and irrational, and if this has caused symptoms, something must be addressed.

During a singing performance, performance anxiety can manifest as feelings of anxiety, tension in the body, panic, being easily distracted, tremors, breathing problems, an increase in heart rate, and even hormone imbalances due to excessive production of epinephrine and cortisol in the body (Kenny, 2011). While all symptoms mentioned above can also occur, the other added signs of someone experiencing MPA are a highly critical and self-evaluative manner before, during, or after the performance, as well as memory failure, suddenly misreading the score despite knowing the

materials well, failures of techniques, loss of posture and excessive production of the adrenaline and stress hormones, epinephrine and cortisol (Osborne & Kirsner, 2022). There may also be the occurrence of behavioral symptoms, such as having the urge to cancel or avoid the performance, or even thoughts of leaving the stage mid-performance. These symptoms presented would almost definitely diminish the quality of the performance and the confidence of the performer. This condition can show up in musicians of all ages and stages of experience, despite the amount of preparation, practice, and training they do. It is likely that having music as the musician's career also added to the amount of persistent stress, therefore even causing a more severe MPA.

Since singing itself is both a physical and mental process, unaddressed performance anxiety can impair the singing performance. This can cause difficulty in controlling a singer's breathing, and this can lead to diminished quality of sound and ability to hit certain notes, as well as affecting a singer's vocal timbre, tone, and projection (Watson, 2019), and, if done too often, might also lead to vocal injuries. A survey was conducted in November 2022 to the majority of third and fourth-year Pelita Harapan University Conservatory of Music voice students. Students filled out a questionnaire regarding their singing experiences, whether or not they have experienced performance anxiety, and if they felt like it limited them from performing to the best of their abilities. 83% of respondents claimed that they feel a significant amount of difference in anxiety level when they perform compared to when they practiced, in a way that affected their performance and their vocal techniques, specifically their breath control. This was also confirmed by the campus' voice lecturers' survey where 80% of them claimed to have seen their students experience this condition and that this highly affects the students' vocal technique, especially their breath control.

Virtual Reality Exposure Therapy (VRET) specifically has been one of the most used VR interventions for dealing with anxiety. It has been used for occupational-related therapy, public speaking therapy, anxiety related to phobias, as well as MPA for instrument players. The idea is to introduce guided exposure to the anxiety-inducing situations gradually, to gain familiarity and therefore decrease the level of anxiety. VR is considered the perfect tool for this, due to how practical and easy it is to simulate said anxiety-inducing situations and cater to different kinds of needs (Donelly et al., 2021). Essentially, VR is made for the users to experience the design, which with creativity, can mean anything one could imagine. It is made to artificially stimulate our senses, may it be visually or auditory, and to "fool" the users to some extent, into feeling a natural sense of presence in a not-so-natural man-made world (Lavalle, 2019; Bruno et al., 2022; Christou, 2010).

The existence of VR provides the possibility of creating a set of experiences that is measured, controlled, flexible, can be created and modified on-demand, and most importantly, safe. In some cases of severe occupational anxiety, it has even been proven that the incorporation of VR in this case allows the clients to receive a more impactful and earlier effect of the therapy compared to the traditional rehabilitation method (Urrely & Martoral, 2023). Gagne, through her article based on the Berklee Teachers on Teaching discussion back in 2015, highlighted how singing in itself is as much of a mental process as it is physical. Thus, a singer's job is also to manage his or her thoughts, which can be a very hard thing to do when someone is too occupied by fear, worry, and anxiousness that can yet be controlled. As of the time this very research was written, there has not been any research specifically on the impact of VR intervention on breath control in singing. However, it was proven through two different studies by Zhang et al., (2021) and Zhang et al., (2022) that the use of VR training has had a positive impact on the overall singing technique, and this includes the breath control technique. In the research Zhang et al., (2021), she studied how the use of VR training impacted a singer's emotions in singing compared to when the singer is only using self-imagination. The study found that because of the emotional activation occurring due to the VR training, the overall singing performance has improved significantly in many areas, including the use of breath control. This finding was then re-confirmed by another study Zhang and her team conducted in 2022, where 35 first and second-year voice major students. Results showed that VR training has brought improvements in the elements of singing technique in general. This is why, the use of VR can be very strategic and impactful for singers and/or voice students, especially towards the breath control itself.

VR can also be used to enhance the teaching-learning process. The use of VR can help students understand certain concepts better, as well as create experiential learning. These days, education is no longer merely about transferring knowledge, but about making sure that students can experience first-hand the concepts that they need to understand. In a teaching-learning experience, technology can be used to help students learn materials that cannot necessarily be brought into the classroom (Endrayanto et al., 2023). Using VR creates a more immersive and interactive learning experience for students, giving a boost to students' motivation and curiosity. The help of immersive media has also been proven to help lower students' cognitive load (Campos et al., 2022). Furthermore, the fact that simulations would also be used created an even further opportunity that allows students to learn in a controlled environment based on a real-life experience. The idea of simulation-based learning can very well be used to maximize the traditional teaching-learning approach, making it even more impactful for the students (Shaw & Switky, 2018).

Thus, using VRET as a tool for controlled and paced simulation for voice students with MPA can get them used to regulating their anxiety while singing, whilst also giving them the opportunity of experiential learning in performing. This method opens an endless opportunity for all kinds of performing situations and conditions that the students might need without direct exposure to an audience or the risk of failing the performance. However, it is also important to note that the steps and methods used in this research cannot be exactly considered as VRET, as it was not consulted with psychologists and medical professionals and was not used to possibly treat the MPA itself. Rather, the interventions were inspired by the steps and systems of VRET and were used to help lessen the symptoms of the MPA.

Other than virtual reality-related treatments, breathing techniques have also been used as a form of exercise to help decrease anxiety. Deep diaphragmatic breathing has been considered one of the best and most effective ways to lessen the feeling of anxiety (Hamasaki, 2020). Interestingly enough, although slightly different in practice, this deep diaphragmatic breathing exercise (DDBE) is also quite similar to the breathing technique used in singing. Therefore, when used correctly and intentionally, the DDBE can also be used to decrease the level of MPA a singer's feeling during a performance, killing two birds with one stone. The idea is to make sure that one breathes deeply and slowly, avoiding shallow breaths and hyper-ventilations which usually make the chest and shoulders rise and cause tension in the body, resulting in a lack of oxygen going into the lungs and can increase the feelings of anxiety (Clinic, 2022; Yau & Loke, 2021; Tompkins, 2010).

The DDBE is done by lying down or sitting down comfortably and placing one hand on the upper chest and the other hand on the person's belly just below the ribcage. This body and hand position will let the person feel the diaphragm move as they breathe in and out. The participants will then be asked to breathe in slowly through the nose and out slowly through their mouths. It is important to note that the hand placed on the chest needs to remain as still as possible, which ensures that the person is fully contracting the diaphragm muscle instead of raising the chest. As the diaphragm contracts, participants engage the stomach or core muscle, therefore when they breathe out the stomach position should go back inwards. The exercise is then to be repeated for a few cycles. The motion of expanding the rib cage and abdominal area, as well as contracting the diaphragm, as well as the repeated cycles of breathing in and out is what makes the DDBE quite similar to the breath control we use in singing (Clinic, 2022; Mirgain et al., 2016).

Up until the moment this research was written, there is very little previous research that studies the impact of VR simulations on MPA, and even fewer studies talk about the impact it may bring on a singer's MPA. While the DDBE has been commonly used to help lessen the general symptoms of anxiety, there is very little to no research that studies the DDBE's impact on a singer's MPA and if this can also bring a positive impact on a singer's breath control technique. This became the heart behind the implementation of this research. The reason why the DDBE is also implemented in addition to the VR simulation is because every singer is different, physically, psychologically, and mentally. This means that there may never be a one-size-fits-all solution to solve this problem, which is why it felt necessary to add another form of tool to the research. Should this study and method be beneficial, this can be a very tangible and impactful way of performing practice, especially in music or art institutions. Thus, this research aims to find out the relationship between VRET simulations on Pelita Harapan University Conservatory of Music's voice-major students' MPA level and breath

control while performing, as well as to see the impact of the DDBE on the students' MPA and breath control while performing.

This research was conducted to study the effect of VR simulation implementation on the MPA level and breath control of Pelita Harapan University Conservatory of Music's voice-major student, as well as the impact of the deep diaphragmatic breathing technique on the MPA level and breath control of the students. It is also to find out the voice-major students' appreciation of the VR simulation intervention. It is hoped that the discovery of this research can further contribute to and motivate the use of VR intervention in singing studies.

METHOD

This research adopts the mixed-method approach, more specifically, the explanatory sequential design type. This means that the data collection and analysis first started with the quantitative approach, and followed by qualitative. While quantitative focuses on analyzing numerical data, finding patterns, and making predictions based on statistical evidence, the use of a qualitative approach gives meaning to those findings. The findings and results of both approaches are then to be interpreted to determine the deeper explanation of the research (Creswell & Creswell, 2017). This research also uses the within-subject research design. In the within-subject design, all participants are given the same interventions. However, the interventions are done in three cycles and on different levels to ensure the authenticity of the data result. This type of experimental research also does not require the presence of a control and experimental group. Instead, each participant becomes their standard, since a comparison is made to the result of each cycle (Simkus, 2023). The sample must also come from a relatively same background, and when the sample of research comes from a similar background. This design has been used mostly in psychological or behavioral-related studies, where the purpose of the research is to study certain methods or ways of treating an illness or certain symptoms (Steingrimsdottir & Arntzen, 2015).

Each intervention consists of three sections: preparation, simulation, and assessment; with a total of three intervention cycles. What differs each cycle is the amount of audience and the size of the performance space, as well as the DDBE intervention that was only given in the third cycle. Below is a detailed explanation of each intervention cycle.

Intervention 1

Figure 1. VR Simulations of Cycle 1
(The Left Picture is the Preparation Section, Right Picture is the Simulation Section)

First, in the preparation section, which lasts for 3-5 minutes, the participants were already asked to wear the VR headset and be shown the visual of a green room or a waiting room where singers would typically prepare themselves before going on stage. Second, the simulation section, in which the visual changes into 3 cycles of performance simulation. The first cycle simulation took place in a small room with 8-15 people in the audience. Third, the assessment section, where voice experts observe and score the participants' breath control for all three cycles using a breath control

assessment rubric. After the performance was done, all participants were asked to fill out the data collection instruments.

Intervention 2

Figure 2. VR Simulations of Cycle 2
(The Left Picture is the Preparation Section, Right Picture is the Simulation Section)

The second cycle, which was done a week after the first one, started the same as the first cycle. The participants were already asked to wear the VR headset and were shown the visual of a waiting room. The simulation section of this cycle took place in a bigger concert hall, with approximately 20-30 people watching. The participants were asked to perform a song of their choice as they would usually do. The assessment section was also done the same as the first cycle, with the voice experts observing and giving scores towards the participants' breath control, as well as the participants filling out the data collection instruments.

Intervention 3

Figure 3. VR Simulations of Cycle 2
(The Left Picture is the Preparation Section, Right Picture is the Simulation Section)

In the third intervention cycle, same as the previous cycles, the students were asked to wear the VR headset and were shown the visual of a waiting room. However, this time, the participants were also given and guided through a DDBE intervention. Thus, the DDBE became a part of their preparation section, to see if it helps with reducing their anxiety level and also their breath control when they perform right after doing the exercise. After they were done with the DDBE and ready to perform, they were shown the visual of the last stage. The last intervention cycle took place in an even bigger stage with about 50-100 people in the audience. The participants were asked to perform as they did in the previous cycles. As in the previous cycles, the voice experts observed all the performances and gave scores on the participants' breath control, while the participants were asked to fill out the data collection instruments. Another aspect that was different in the third cycle was the focus group discussion that was only conducted at the very end of the third cycle. After finishing the last simulation cycle individually, participants were divided into groups and given a few open-ended questions regarding the research they had taken part in.

As depicted in Figures 1, 2, and 3, every cycle provides a different visual and a different simulation experience. These simulation videos were all recorded using a 360° camera to create

realistic visual effects during the simulation. This type of camera also allows the participants to be more flexible with the direction of their sight. Simply put, they can look in any direction and the visuals would all still be connected, just like how it is in real life. The VR headset used in this study in particular is the Oculus Quest 2.

The first data collection instrument used in this research is the modified Kenny – Music Performance Anxiety Inventory (K-MPAI) Questionnaire, which consists of a self-assessment instrument made by Dianna T. Kenny, a leading expert in the field of MPA. The original instrument consists of 40 items, however, this research only used 21 items related to the music performance anxiety symptoms. This was done to ensure the relevance of every single item in the questionnaire filled by participants. Items that are considered a part of other factors such as parental support, depression and hopelessness, memory self-efficacy, and generational transmission of anxiety were not included in the final questionnaire used (Philippe, 2022). This is because this research focuses solely on the difference that the intervention may bring to the MPA symptoms. Furthermore, the writer also added four additional items to further study the effect of the VR simulations on certain MPA symptoms, such as breathing. Upon conducting the validity and reliability test of the questionnaire, seven items were found invalid and omitted from the research. This left us with 18 valid items. The Cronbach alpha formula was then used to check the reliability and came back with a score of 0.91, which means that the questionnaire was reliable. This questionnaire is to be scored with a seven-item Likert scale. The modified K-MPAI questionnaire has already been translated into more than 20 languages, and in this research, it is presented to the participants in Bahasa Indonesia and English, so that participants can choose whichever language they feel the most comfortable with.

Table 1. K-MPAI Questionnaire Pearson Correlation Validity Test

No.	Item Nr	r_{count}	Validity Status
1	1	0.527	Valid
2	2	0.687	Valid
3	3	0.738	Valid
4	4	0.758	Valid
5	5	0.043	Invalid
6	6	0.669	Valid
7	7	0.754	Valid
8	8	0.655	Valid
9	9	0.488	Valid
10	10	0.258	Invalid
11	11	0.472	Valid
12	12	0.619	Valid
13	13	0.688	Valid
14	14	0.668	Valid
15	15	0.517	Valid
16	16	0.744	Valid
17	17	0.191	Invalid
18	18	0.610	Valid
19	19	0.580	Valid
20	20	0.456	Valid
21	21	0.279	Invalid
22	22	0.492	Valid
23	23	0.342	Invalid
24	24	0.227	Invalid
25	25	0.507	Valid

Table 2. K-MPAI Questionnaire Reliability Test

No.	Indicator	Mark
1	Variance Sum	48.263
2	Total Variance	352.766

No.	Indicator	Mark
3	Cronbach's Alpha	0.911
4	Reliability Standard	0.7
Conclusion		**Reliable**

During the performance simulation, each participant was observed and examined by the vocal experts using a rubric made specifically on breath control in singing. In making the rubric, statements that are used as parameters to measure out the participants' breath control execution were already discussed with vocal experts, as well as referring back to the theories of breath control used in the literature review of the research, to ensure its relevance and appropriateness to the topic. The rubric consists of seven statements and uses the 5-point Likert scale. All seven items of the rubric were found valid through a validity test with a reliability score of 0.98, meaning that the test is considered reliable. The item of this rubric aims to measure if the participants have executed the proper breath control, along the different weeks, they have improved their breath control, as well as studies the impact and connection of the proper breath control they do towards other aspects of singing, such as dynamics, vibrato, pitch control and more.

Table 3. Breath Control Rubric Validity Test

No.	Item Nr	r_{count}	Validity Status
1	1	0.884	Valid
2	2	0.958	Valid
3	3	0.965	Valid
4	4	0.982	Valid
5	5	0.962	Valid
6	6	0.974	Valid
7	7	0.956	Valid

Table 4. Breath Control Rubric Reliability Test

No.	Indicator	Mark
1	Variance Sum	10.357
2	Total Variance	65.895
3	Cronbach's Alpha	0.993
4	Reliability Standard	0.7
Conclusion		**Reliable**

The last form of data collection in this research is focus group discussion (FGD), where participants were divided into small groups and were given questions to which they could respond and discuss within a controlled environment. Since the research is conducted in class settings and each participant is using the same simulation video each cycle, it is safe to say that they would share a common experience. However, despite the shared experience, it is still possible for their experiences to have small differences. Therefore, it is quite appropriate for this research to utilize this method of data collection. This also allows the participants to suggest feedback in a more comfortable way, as well as making the process easier to organize and much more effective than if the research used one-on-one interviews (Ugwu & Eze, 2023). The data would then be analyzed with the thematic analysis technique, which is a method commonly used in qualitative research where each data set is systematically organized and analyzed by searching for themes and patterns (Dawadi, 2020). This research specifically used the inductive approach, meaning that the data of this research was coded without actually trying to fit it into a coding framework that was previously determined. Instead, the data found was analyzed, categorized, and interpreted according to the number of occurrences and the need of the research questions (Dawadi, 2020). For something to be considered a theme, it has to occur for a significant number of time and has an interesting contribution to the data (Maguire & Delahunt, 2017). In this study, the patterns and themes that will be further discussed are only those with an occurrence of more than 50%.

This research was conducted at Pelita Harapan University Conservatory of Music, with a total of 19 participants (F=10, M=9) who are all active voice students in the faculty, with ages ranging

from 17-21. Every single cycle was implemented as a part of the participants' Performance and Practice Evaluation (PPE) class. PPE Class is a mandatory class for all voice students of Pelita Harapan University Conservatory of Music that focuses on teaching the students how to perform and sing well on stage. Compared to their voice major class where they would focus more on learning certain techniques and how to interpret a song, PPE class is where the students would typically learn how to handle themselves in front of an audience, how to use and maximize a stage, how to present themselves well as a singer, and more. All in all, the class focuses more on stage presence and performing in itself. Thus, it is very fitting that this research was held as a part of the class temporarily. It is also important to note that since all participants are voice students, they have already learned the basic singing techniques that are being observed in this research.

RESULTS AND DISCUSSION

Results

The results found in this study will be presented in four sections according to the research questions (RQ).

RQ 1 – to what extent does the use of VR Simulation Influence the Music Performance Anxiety Level of Pelita Harapan University Conservatory of Music's Voice Students?

This specific research question uses repeated measures ANOVA, a quantitative data analysis that is commonly used for within-subject research to specifically measure the difference between three or more cycles. For F statistics results to be considered significant, the p-value has to be below the significance standard of 0.05. However, the p-value found was 0.357, suggesting data results that lean toward the null hypothesis. This result means that the difference found was not significant due to the limitation of the data collection.

Table 5. Repeated Measures ANOVA

No.	Source	SS	df	MS	F
1	Time	55.586	2	27.293	0.918
2	Error	1453.719	46	30.286	
3	P-value	0.357			

To explain this further, we refer to the qualitative Data found through the forum group discussion. Through the process of thematic analysis, finding themes, and patterns, and creating codes to further categorize the qualitative data findings, it was found that most participants had positive perceptions, but with a few notes and inputs. Participants agreed that despite knowing that they were using VR, to some extent, the simulation still did feel like performing. This allowed them to practice using a tool that helps them manage their anxiety without the risk of actually embarrassing themselves or panicking in the middle of a performance. However, a lot of participants also rightfully mentioned how anxiety is typically not something you can fix in a short period, and so is a singer's MPA. Some participants also suggested that in the future, this can be done more frequently or for a longer period, to fully maximize the potential this method may bring.

The findings of both data analyses suggest that the hypothesis in favor of the research question was rejected, and instead is to accept the null hypothesis (The implementation of VR simulation did not improve the participants' MPA level significantly). In conclusion, there were some changes and improvements found, however it was just not significant enough statistically.

RQ 2 - to what extent does the use of VR Simulation Influence the Breath Control of Pelita Harapan University Conservatory of Music's Voice Students?

To determine if there was improvement in the breath control score of the participants, we first need to find the score mean and standard deviation of each cycle. The mean is used to see the overall improvement of the score, while the standard deviation is used to determine the dispersion of the

data towards the mean. The result of the standard deviation would then be used in the Coefficient of Variation (CV) formula to tell if the value of the standard deviation compared to the mean is big or small. Results showed that there were improvements in the overall mean score (Cycle 1 = 22.158, Cycle 2 = 23.026, = 25.803). Results also showed that the CV value found was considered low (below <1), meaning that there was a similarity in the data gathered in each cycle and that the data were not dispersed far from the mean (Cycle 1 = 0.167, Cycle 2 = 0.129, Cycle 3 = 0.129). Thus, it is safe to conclude that the improvement shown in the result happened to the majority of the participants.

Table 6. Mean & Standard Deviation Comparison of Cycles

No.	Variable	Cycle 1	Cycle 2	Cycle 3
1	Mean	22.158	23.026	25.803
2	St. Dev	3.690	2.971	3.320
3	CV	0.167	0.129	0.129
4	Level of St. Dev	Low	Low	Low

Forum group discussion findings showed that a lot of the participants realized that theoretically, this can very much impact their breath control positively. The fact that by using the VR simulation they can get to practice handling their anxiety level towards the audience as well as maintain their breath control at the same time was the reason most of the singer stated that although it has not impacted them very significantly, they believe if this is to be done for a longer period or more frequently, this can be very impactful towards their breath control too. With this in mind, it is safe to reject the null hypothesis and accept the alternative hypothesis, suggesting that there was an improvement in the participants' breath control. However, this improvement can be even more significant if it is conducted for a longer period or more frequently.

RQ 3 - to what extent does the use of the Deep Diaphragmatic Breathing Technique in Singing Influence the Music Performance Anxiety Level of Pelita Harapan University Conservatory of Music's Voice Students?

Further analysis was done to analyze whether the results of DDBEs impact the participants' MPA levels. Upon comparing the mean score difference of Cycle 1 – 2 (no DDBE) and Cycle 2 – 3 (with DDBE), it was found that Cycle 2 – 3 had larger differences, meaning that there were more improvements. However, paired t-test results suggested that the difference was still not significant enough (p-value = 0.665). Interestingly, the results found in this area of the research were not linear with the qualitative data. Almost every single participant was excited to elaborate on how the exercise truly helped them relax and feel less anxious. They discussed how it helped them regulate their anxiety level, as the exercise would also help lower their heart rate. Despite the exercise only being conducted for 1-2 minutes, participants stated that this truly impacted them positively.

Table 7. Mean Difference of the Cycles

No.	Variable	Cycle 1	Cycle 2	Cycle 3
1	Mean	86.105	85.158	84
2	Mean Difference 1-2		0.947	
3	Mean Difference 2-3			1.158

Upon finding the discrepancy between the results of qualitative and quantitative data analysis, it is possible that, even though the exercise was deemed quite helpful in this study, the lasting effect was not longer than we expected. This may also be due to the possibility of situated anxiety. When a person has consciously or subconsciously associated a certain scenario with worry and nervousness, this may result in them being involuntarily falling into the gap of being anxious every single time he or she is exposed to said scenario, which in this case, is performing. Again, this is an assumption made to possibly explain the contradictory result, however further tests are needed in this area to further study these preliminary new findings.

Secondly, taking the effect of the DDBE on the participants' breath control into further consideration. The results suggested that there was quite a difference in mean score between Cycle 1-2 (0.868) compared to Cycle 2-3 (2.776). Furthermore, the paired samples t-test found that both

the changes in Cycle 1-2 and Cycle 2-3 were significant. However, the p-value of Cycle 2-3 (0.0001) was considerably a lot smaller than the p-value of Cycle 1-2 (0.009), meaning that the improvement found in Cycle 2-3 was much more significant.

Table 8. Mean Difference of the Cycles

No.	Variable	Cycle 1	Cycle 2	Cycle 3
1	Mean	22.158	23.026	25.803
2	Mean Difference 1-2		0.868	
3	Mean Difference 2-3			2.776

Forum group discussion results showed that at least half of the participants felt that the application of DDBE helped participants refresh their minds and muscle memory towards the breath control technique that they use in singing. This also explained the significant improvement that occurred in the result of the paired samples t-test of Cycle 2-3. Thus, we can reject the null hypothesis and accept an alternative hypothesis, which is that the application of DDBE improved the participants' breath control significantly.

Table 9. Paired Samples T-test

No.	Variable	Cycle 1-2	Cycle 2-3
1	Mean of Difference	0.947	1.158
2	T-tesd	-0469	-0.440
3	P-value	0.645	0.665
4	df		18

RQ 4 – Pelita Harapan University Conservatory of Music's Voice Students' Appreciation Towards the VR Simulation Implementation

This specific research question only used the qualitative approach with data gathered through forum group discussion. The first and one of the most frequently mentioned themes was how the experience was very fun for the participants. They mentioned how it was a completely new and positive experience for them. Furthermore, another common theme was how the participants found that by using the VR simulations, they could truly prepare themselves for the 'real thing'. Most participants stated that the simulation gave them a considerably realistic performing experience. They mentioned that to some extent, they can still feel the anxiousness and the nervousness they usually get when they perform. However, the degree was not the same as when they were performing, meaning that despite being quite realistic, it did not 100% feel like a real performance. Another common theme related to this one is how the blurriness of the video in the VR simulation affected the realistic feeling in the simulation. It was also found that participants saw the VR simulation as something that should be applied in a long-term duration and frequently as a part of their class in the future should this be possible. Despite the imperfections found in the research, none of the participants in this research were against implementing this in class.

Discussion

The insignificant result found through the quantitative data analysis has brought the researchers to do deeper literature research on previous studies. Since this specific approach has never been done on singers or voice students, we cannot be 100% sure whether the findings of the literature review would also apply to this type of research specifically. However, it was found that generally, it takes 6 to 14 weeks for VR-based simulations or therapies to have long-term effects (Hawajri et al., 2023). The implementation of VRET on agoraphobia and social phobia is only effective when performed for 8 to 12 sessions on different weeks for at least 15 minutes per session (Krzystanek et al., 2021). Bellinger et al., (2023) conducted research in 2023 on the application of VRET and relaxation training in MPA and found that VR-based exposure treatment can help encourage musicians and improve their self-efficacy, as musicians would be able to transfer and apply what they experience in the simulation. Furthermore, when only used in a short period and/or

small frequency, VRET could still be a good intervention used to decrease sympathetic activation and lessen the symptoms of anxiety itself. In other words, while the VR simulation helped improve some MPA symptoms, it was not long and extensive enough to be considered as a treatment for the MPA itself.

Despite the discrepancy of the findings, the researcher found that it is important to further highlight the qualitative finding where participants elaborated in unison on how the DDBE helped them feel more calm and relaxed during the performance afterward. Watson (2014) mentioned in his journal, that an ideal singing performance requires a relatively stable and relaxed body and mind. All in all, as previously discussed in the literature review, the uniqueness of a singer's voice character is formed by the difference in anatomy they have, from the way their vocal cords, mouth, nose, and throat area are built slightly different from each other. Thus, there is no one-size-fits-all solution to fix every singer's singing problem. Every singer is built physically, mentally, and psychologically differently, and thus, they may also need different ways to improve their voices (Watson, 2014).

The findings of this study have to be seen in light of some limitations. The limitation of time and funding is considered one of the major factors. This resulted in the finding of the result being not as significant as one may hope or predict. This was also confirmed by how most participants saw the potential of this method, however, they did not quite get the full impact because the intervention was only conducted in a very limited frequency and duration. The second limitation concerns the sample size of the research. Even though the sample of this research was the whole voice student population, it was still considered a small sample size. Should this method be conducted in a bigger population of voice students and/or singers, there may be an even more elaborated and impactful explanation of the questions being asked in this research.

Furthermore, very little to no research has been done to specifically study the impact of VR implementation on a singer's MPA or breath control. This makes it more difficult to plan out a design that may work as well as one may expect. The next limitation of the study touches on the fact that although the simulation was designed and is supposed to imitate real-life performing experiences, quite a few participants brought up how it did not feel 100% real. In reality, there were aspects in performing that this research was not quite able to imitate in the simulation. Some of the factors that contribute to this are the visual and the level of interactivity of the simulation. In conclusion, there is no such thing as perfect research, and this one too, is most definitely not perfect. Findings and analyzation results we see in a research must always be taken with a grain of salt, especially if the reader means to use said research as a reference for their research.

As previously mentioned, this specific research was conducted in the Performance & Practice Evaluation (PPE) Class of Pelita Harapan University Conservatory of Music, whose main purpose is for voice students to be able to learn and practice performing in front of an audience and on a real stage. The VR simulation became the perfect tool for voice students to experience performing in front of an audience and on a real stage when they are just in class. This means that in the long run, it is wise to further incorporate this VR simulation method in class, to enhance the learning experience even more. Findings of this research suggested that this method is applied for a more frequent or longer duration of time. Thus, it might be good to apply this method as a routine way of practicing (once a month, for example), so that students may prepare the performance even better and so that the teachers or lecturers have time to prepare the simulation videos. This method can also be used to cater to whatever needs or topics the class may be discussing at the time. All in all, the flexibility and adjustability of VR simulation allow us to provide all kinds of simulations to the voice students.

With the limited amount of previous studies and references regarding the use of VR simulation designed specifically to help with a singer's MPA level, it is hoped that the findings of this research can contribute theoretically to future research. Not only that, although this was initially designed to be used on singers, with some adjustments and adaptations, this method can be tried on other musicians or instrument players, on different levels of musicality, other aspects of singing techniques, and many more. It is also highly suggested that future researchers conduct this research in a longer duration of time and/or frequency, to ensure the significance of the result. To further prove the effect of VR simulations on a singer's MPA level and breath control, it is also suggested that future researchers attempt to conduct this research whilst applying a different experimental

research approach, where the presence of a control group and the experimental group can be used to simultaneously compare the progress between those who use the VR simulations and those who don't. This research in particular was also very limited in sample size. This research was done specifically on the population sample of 19 voice students of Pelita Harapan University Conservatory of Music. Since the population sample size can be considered quite small, it is highly suggested that fellow researchers with access to singers and/or voice students can try conducting this research on a different set of population samples and with different sample sizes as well.

CONCLUSION

It is safe to say that there were quite a few favorable and valuable findings in this research. Despite all the limitations that occurred, the VR simulations did impact the participants positively, especially in helping them be more familiar with performing situations. In other words, this way of practicing singing and learning allows them to get themselves ready for the real performances they have to face in the future. The fact that this method opened up the possibility and the opportunity of students being able to perform anywhere from the space of their campus, truly showed the potential of this method and what it can do to deepen and enhance the participants' learning experience on campus.

However, it is also important to note that performance anxiety and the mastery of breath control is not something that can really be changed and improved in such a short period, or if not done consistently and continuously. Rather, it is a process that must be done for a longer period for singers to feel a significant change and for listeners to notice the improvements. With this in mind, should this research be conducted again in the future, researchers can consider more on the duration and frequency aspect of the intervention, to further maximize the impact of the intervention and to gain a long-term effect. It is also suggested that future researchers try to expand the sample size towards singers or voice-major students from different institutions or different musical backgrounds. It is hoped that in future studies, researchers will be able to collaborate with not only voice and singing experts but also psychologists, psychiatrists, or any medical professionals who could help review and develop the VR interventions for an even better outcome. All in all, it can be concluded that this study has provided valuable insights and set the stage for future research, especially into the use of VR in music education, vocal studies, as well as anxiety management for singers and voice-major students.

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Transforming music learning: Keroncong guitar VSTi prototype as a catalyst for educational innovation

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ABSTRACT

The rapid development of technology in music education requires music educators to be creative and critical in developing technology-based learning tools. This ensures that learning aligns with current trends and is implemented more effectively. In addition to enhancing learning, technology also addresses challenges faced by music composers. This study focuses on creating a Virtual Studio Technology Instrument (VSTi) for the keroncong guitar as a teaching aid. In keroncong music, the guitar plays a key role in improvising chord progressions, demanding specialized skills from musicians and composers. Using a practice-oriented approach, this study covers the pre-production, production, and post-production stages of developing a VSTi for the Keroncong guitar. The results show that the VSTi operates effectively in a Digital Audio Workstation (DAW), serving as a valuable learning tool and reference for keroncong guitar patterns. The assessment demonstrated significant improvements in sound quality and user satisfaction, with 90% of users approving. Integration with other instruments showed a 25% average improvement, while flexibility and ease of improvisation received positive feedback from 80% and 75% of users. To conclude, the prototype of the Keroncong Guitar VSTi can catalyze educational innovation.

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INTRODUCTION

Keroncong music is an original Indonesian music that has developed since the 16th century. This music has reflected the identity and personality of the nation and has been translated internationally. In its revolution, keroncong music cannot be separated from the contribution of today's youth (Supiarza et al., 2018). Many have proposed this keroncong music as a world heritage (Alfian, 2013). Keroncong music, influenced by the contribution of young people, has developed significantly. At first, keroncong music had its own rules, but over time, the younger generation has expressed songs from the West that are played in the keroncong style. This change shows the special challenges faced by keroncong musicians, especially in the aspect of improvisation.

These challenges include the need to adapt new elements from various genres while maintaining keroncong identity, including the barriers that musicians often face in terms of improvisation. This study aims to develop a virtual keroncong guitar instrument to help musicians overcome these challenges while providing an effective learning medium for them. Instruments in

keroncong music generally include cak, cuk, cello, violin, flute, and guitar. In its development, keroncong music can also be said to be hybrid music where the concept of local and global culture through the adaptation of Western concepts is found in the aesthetics of keroncong music (Yulfita & Asril, 2023).

Keroncong guitar is one of the main highlights in the discussion of this study. The concept of guitar playing in keroncong music as explained by R. Agoes Sri Widjajadi in Kusumah (2021) is that the concept of playing the keroncong guitar is a series of melodies that go up and down from the chord description with a note value of 1/8 and 1/16 and is done improvisationally; thus, technically, it is necessary to have the ability to improvise with the guitar in keroncong music. In terms of style, the guitar plays as an accompaniment in improvisation by paying attention to the running chords. Therefore, the improvisation is not as free as imagined, but it follows the chord progression being played, hence, the notes played are chord improvisation called arpeggios. Improvising using musical instruments is often found in jazz music.

There are various principles in doing an improvisation. Improvisation skills need to be possessed by every musician who wants to do improvisation for various types of music (Hidayatullah, 2023; Kusuma & Karwati, 2024). One developed idea of keroncong music improvisation is adding a passing tone, which means adding one note before going to one of the notes on the chord that will be chromatically forward or backward. However, the skill of improvising is not possessed by every musician or music educator (Larsson & Georgii-Hemming, 2019). Therefore, the researchers felt challenged to transform the keroncong guitar playing pattern into a virtual instrument that can be used as a learning medium for keroncong guitar and can also be used as a virtual instrument that can help keroncong music composers who have limitations in playing keroncong guitar. The virtual instrument was designed through the operation of a Digital Audio Workstation (DAW).

According to Leider (2005), DAW is a software that functions to edit and memorize audio digitally. This software can also function as a sophisticated recording studio by using plug-ins and special software that can produce studio-quality sound through computerization. Furthermore, DAW does not only function to record music but also allows users to create a virtual musical instrument through a recording mechanism. It is also a real form of technological development in music and is often used by music composers in composing a composition in various genres (Reuter, 2022). This shows that there are great opportunities provided by DAW to create various musical compositions performed by music composers. In the world of music education, DAW is often used as a learning medium in digital music (Bennett, 2016; Chrisanto et al., 2021; López-Íñiguez & Bennett, 2021). The use of information technology has enabled individuals to learn music better (Cipta, 2021; Duncan, 2021; Malaschenko et al., 2020).

Paul Middleton and Steven Gurevitz in Frenki et al., (2018) stated that a virtual instrument is computer software that produces sound from a musical instrument called a Virtual Studio Technology Instrument (VSTi). Furthermore, VSTi is used as a substitute for the original musical instrument and to create a musical composition, so that the sound of the musical instrument is digitally used. Generally, it is played using a MIDI Controller. According to Ramdani & Sukmayadi (2023), the use of VSTi in music production can be a solution to the limited access of people to traditional musical instruments. Furthermore, productivity in limited space becomes an expression that can be explained through the role of technology in overcoming the situation. VSTi's ability to simulate playing musical instruments makes music production more effective. Thus, VSTi is one example of technological progress in music. This can be a solution for music composers who have limitations in producing music using musical instruments that are difficult to access. In this study, researchers used a DAW called Logic Pro to process audio using the Virtual Guitar Instrument that is available from Logic Pro. The audio recording that was done began by drawing the notation of the keroncong guitar playing using the piano-roll feature in the DAW. The notation that has been made is then exported into a file with the format .wav based on the notation pattern that has been grouped.

In accordance, the increasingly rapid development of technology in music arts education has implicitly instructed that educators need to be able to be creative in utilizing technology for music arts education. This needs to be done as an effort to provide the best experience for students (Cano et al., 2018; Portowitz et al., 2014; Wise et al., 2011). In line with that, Swanwick (2001) explains

that music technology, cultural heritage, and music arts education have a mutually influential relationship with each other. It is further explained that music technology influences how we inherit music and this shows how we influence the world of music arts education. Swanwick added that through technology in music arts education, it is possible to overcome the problem of poverty. Thus, music education should also consider technological developments in understanding and inheriting music from time to time. Pratama & Latifah (2023) argue that currently, individuals who work in the music field can produce music through various choices of music software such as Kontakt Library, DAW, and MIDI as a means of creating and learning music. However, over time, renewal and innovation need to be carried out to inherit, develop, and preserve every aspect that has value in the world of music arts education (García-Gil et al., 2022; Nart, 2016).

Based on the background issue, the researchers first conducted a comparative study of the research to be conducted with previous research to find gaps that could be used as new information in this study. A study by Pratama & Latifah (2023) developed a virtual drum instrument, highlighting the need for a tool that can preserve local culture-based music. Meanwhile, Gunawan (2023) discusses the development of a virtual jaipong drum instrument as an effective musical creativity tool to preserve and promote local music rooted in traditional culture. Furthermore, Frenki et al., (2018) explore the process of transforming audio from the Payokumbuah kecapi instrument into a virtual instrument. These three studies show that the keroncong guitar as a virtual instrument has not been widely developed. Thus, this study aims to build on previous work by developing a VSTi of the keroncong guitar. This initiative is expected to address the gap in the tools available for keroncong music education, as well as contribute to the development and preservation of keroncong music among the younger generation.

METHOD

This study is explained descriptively through a qualitative approach through practice-oriented research. According to Hendriyana (2021), this method can be used as a method of creating works that are part of artistic research. The purpose of artistic research is to produce a deeper understanding of the creative process, artwork, and personal experiences that underlie the creation of art (Budiawan & Martyastiadi, 2020). The steps taken in developing keroncong guitar VSTi are divided into three stages as follows in Figure 1:

Figure 1. Development Stages of Keroncong Guitar VSTi

This methodology involves three stages: pre-production, production, and post-production. First, in the pre-production stage, an analysis of improvisation patterns in keroncong guitar playing, a review of relevant information, and a classification of various playing patterns to be designed were conducted. Second, in the production stage, a recording was conducted to create an audio sampling of keroncong guitar playing patterns using DAW, including placing audio samples in the Kontakt library, as well as scripting and designing the Kontakt GUI. Lastly, in the post-production stage, a trial of the VSTi that had been produced in a keroncong music arrangement using DAW was conducted. In general, this study focuses more on the pre-production and production stages. To validate the data, user feedbacks from educators and students were collected to ensure the effectiveness of this VSTi. This feedback was used as a success criterion in evaluating how well the VSTi functions as a learning and improvisation tool in keroncong music.

RESULTS AND DISCUSSION

Results

This sub-section presents the findings and discussion regarding the pre-production and production of the Keroncong guitar VSTi design:

Pre-Production

Based on the results of observations, various improvisation patterns were found in keroncong guitar playing. According to Kusumah (2021), the movement of the keroncong guitar playing is melody. The rules of the stepped tone movement, both semi and whole-tone, provide density between harmonic intervals. The improvisation technique used always relies on non-harmonic tones, which are melodic structures that use tones other than the ones that apply in the chord. After conducting observations, the researchers designed the two keroncong guitar playing patterns, namely ascending and descending, by playing chord arpeggios in 12 major and minor tonalities contained in staff notation, examples are below:

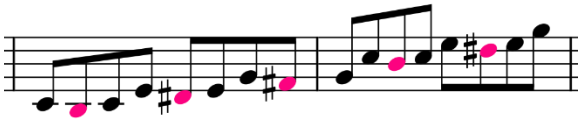

Figure 2. C Major Ascending Arpeggio Pattern using Passing Tones

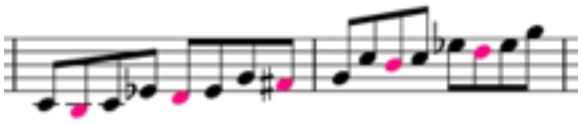

Figure 3. C Minor Ascending Arpeggio Pattern using Passing Tones

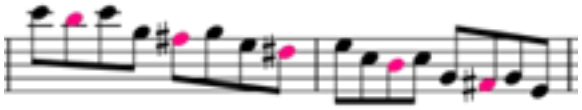

Figure 4. C Major Descending Arpeggio Pattern using Passing Tones

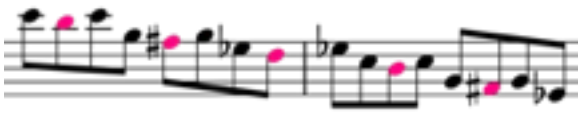

Figure 5. C Minor Descending Arpeggio Pattern using Passing Tones

The figures above are patterns presented in the keroncong guitar VSTi developed by the researchers. The notes in red are passing tones or non-harmonic tones from the C major or C minor chord. As explained by Kusumah (2021), passing tones are non-harmonic tones that move in the same direction as the chord closest to the intended tone. The patterns used are divided into two, namely ascending, which means the melody moves from low to high notes, and descending, which means the melody moves from high to low notes. In the VSTi presented, these patterns are arranged in a system of 12 tonalities.

Production

The production stage was carried out to realize the research plan in making keroncong guitar VSTi by recording guitar playing patterns with notations that had been made in the pre-production stage. The recording process was carried out simply through DAW operation, without a conventional recording mechanism. The creation of this VSTi aims to create a keroncong guitar improvisation playing pattern, thus, the researchers recorded the guitar playing pattern through the guitar VSTi that

was available in DAW. In the first stage of production, the researchers entered the guitar VSTi available from the DAW and then created a new track, see Figure 6.

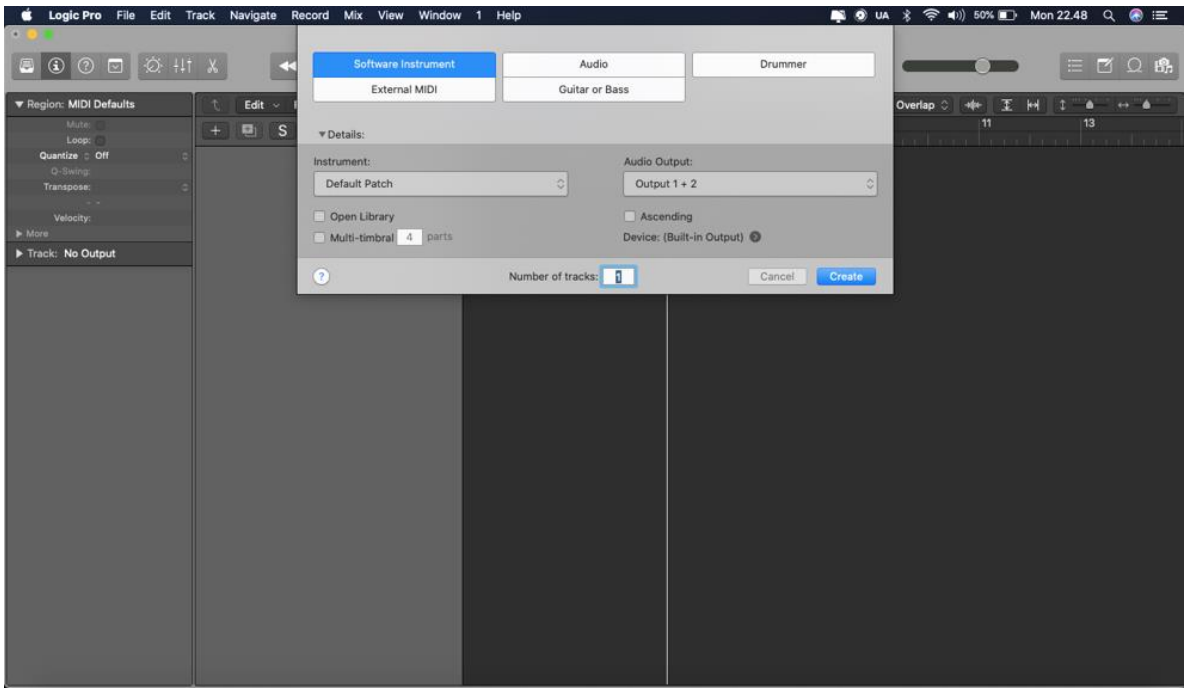

Figure 6. Initial View when Opening Logic Pro DAW

At this stage, the researchers created a new track by paying attention to the instrument source and output channel used to create the keroncong guitar VSTi improvisation pattern.

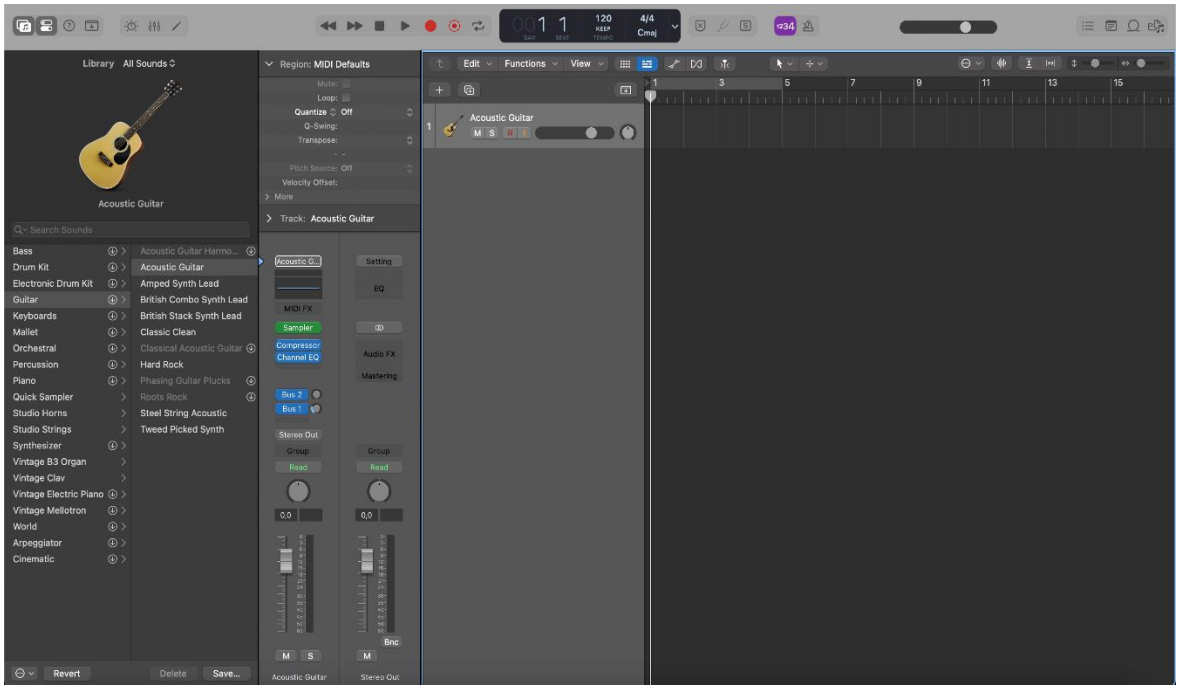

Figure 7. Screen View of Logic Pro DAW

At this stage, as shown in Figure 7, the researchers selected VSTi in the instrument column in the DAW as a virtual instrument used to work on the notation of the keroncong guitar playing pattern.

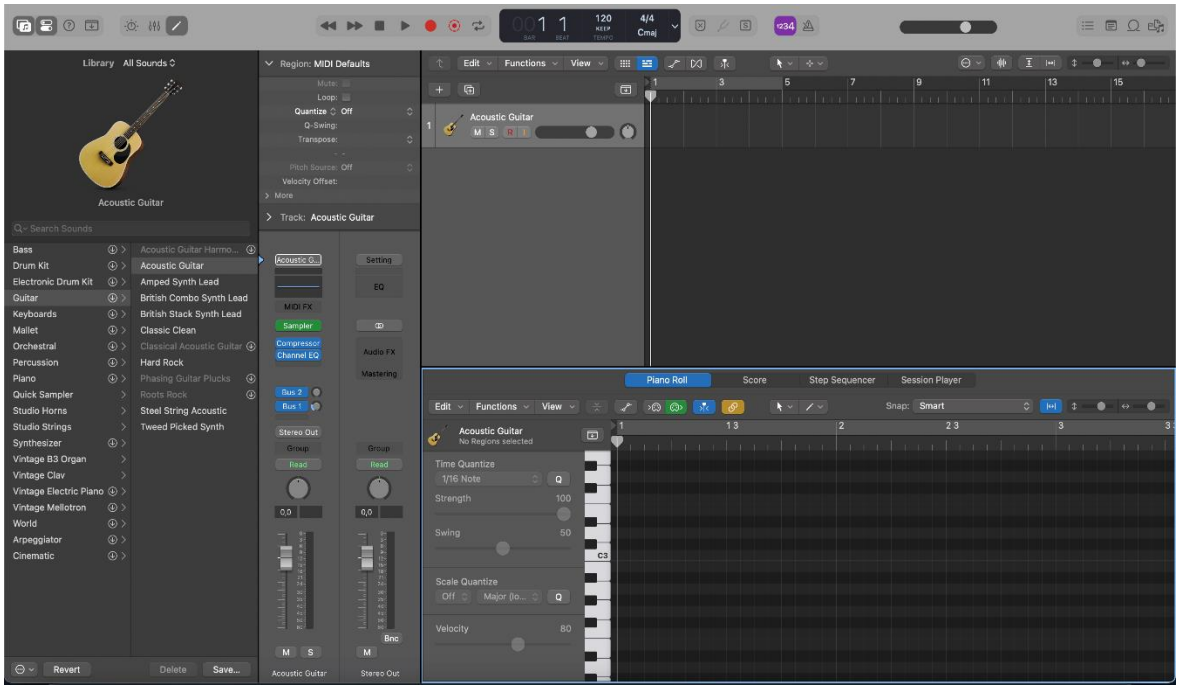

Figure 8. Logic Pro DAW - Piano Roll View

At this stage, the researchers opened the piano roll section. Here, the piano roll can be accessed by pressing the scissors symbol located at the top left of the screen. It can be seen that the piano roll was divided into several octave registers, in this VSTi the lowest note was on the E key at C1.

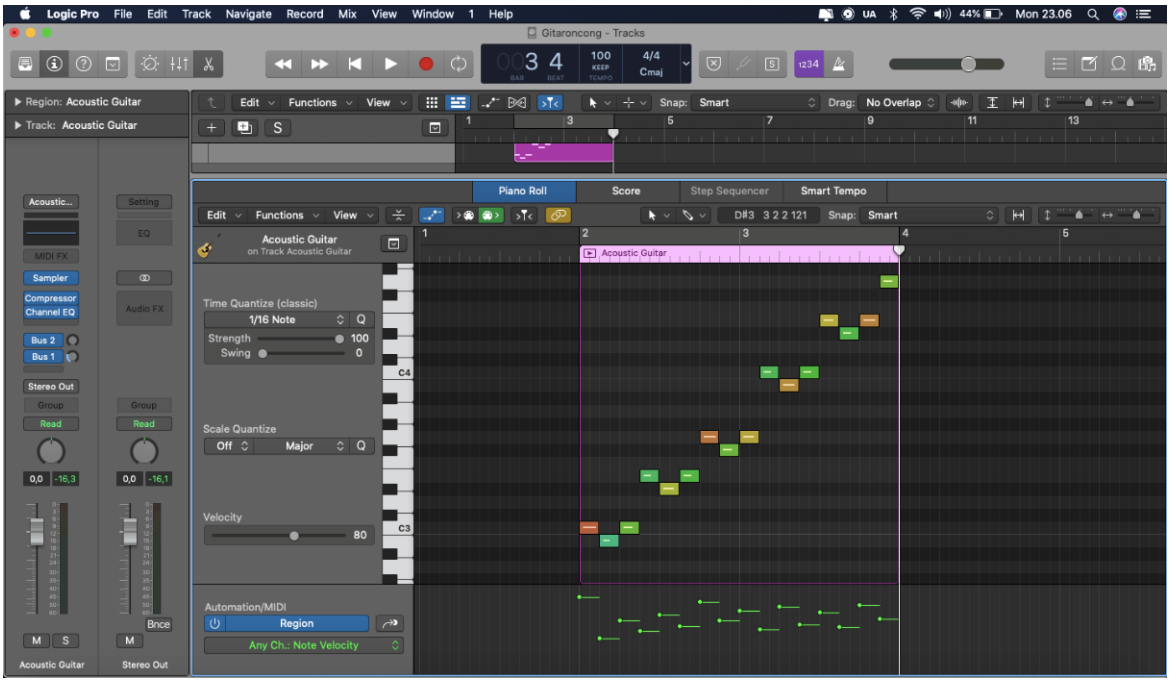

Figure 9. Transforming Staff Notation on Piano Roll Logic Pro DAW

At this stage, the notation that was prepared during pre-production was made into a piano roll. The researchers adjusted the velocity of the notes that have been loaded into the piano roll to make the guitar playing feel realistic and the dynamics are not monotonous. Then, the audio was exported into .wav format. After that, the notation creation was repeated based on the tonality system and the direction of the melody movement as previously planned. After exporting, researchers classified the files based on the notations they had created (see Figure 10).

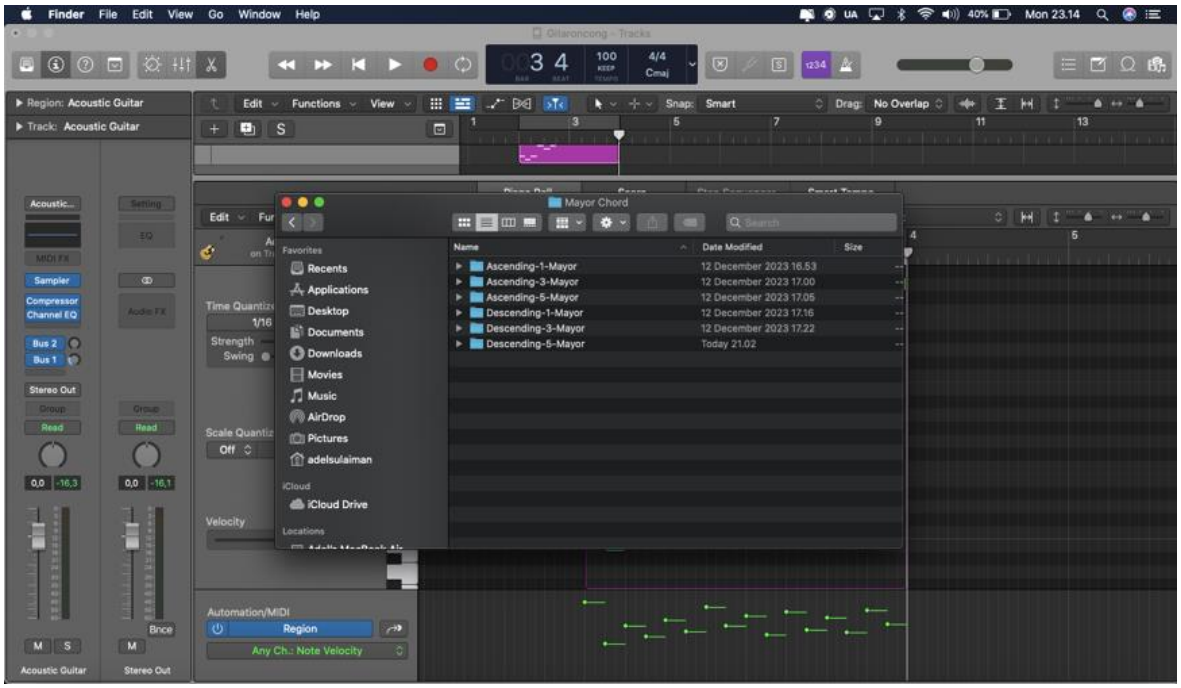

Figure 10. Classification of Exported Audio Results

Folder classification was made based on the major and minor systems of exported patterns and the direction of melody movement. Audio data were loaded into one grouped folder to make it easier to map to the Kontakt Library later. The audio mapping stage is presented in Figure 11.

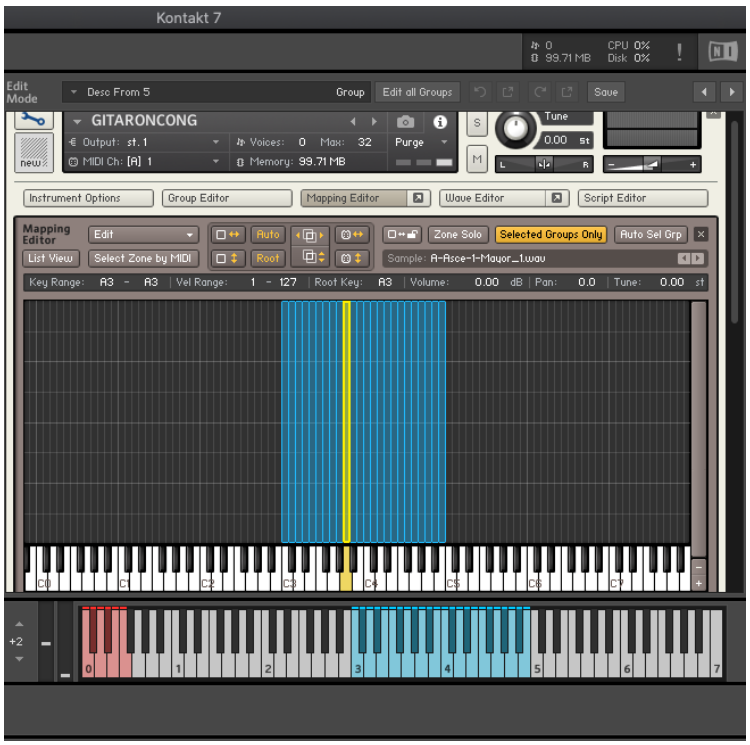

Figure 11. Exported Audio Mapping

As seen in Figure 11, the classified audio file mapping was loaded into each group of piano keys available in the Kontakt Library based on the tonality of each audio sample. Then, it was followed by grouping the loaded groups and creating key switches, which can be seen in the red piano keys above.

Post-Production

Post-production is an important stage in the development of VSTi Gitar Keroncong, where the testing and assessment processes were carried out to ensure the functionality and quality of the virtual musical instrument that has been created. At this stage, VSTi was tested in a keroncong music composition, involving various instruments such as cak, cuk, and guitar. This process was carried out to assess how the VSTi was integrated with other instruments and how well it was able to maintain the characteristics of keroncong music.

The test results show that the VSTi Gitar Keroncong did not only work well in conveying the energy and nuances of keroncong music but also provided users with a variety of options in terms of accessibility and ease of improvisation. Table 1 below summarizes quantitative data on the results of post-production testing, providing an overview of how users perceive the effectiveness of the VSTi in practice.

Table 1. Export Audio Mapping

No.	Assessment Aspects	Total Compositions	Average Improvement in Sound Quality	Percentage of Satisfied Users
1	Ability to Integrate with Other Instruments	10	25	85
2	VSTi Sound Quality		30	90
3	Flexibility in Playing		20	80
4	Ease of Access for Improvisation		15	75

From Table 1, gitar keroncong VSTi demonstrated consistent improvement across various assessed aspects. The 30% average increase in sound quality indicates that the VSTi successfully produced a more realistic sound, closely matching the characteristics of keroncong music. With 90% of users satisfied with its sound quality, the VSTi met the expectations of musicians. Its ability to integrate with other instruments, such as cak and cuk, resulted in a 25% average improvement, facilitating harmonious reproduction and offering a richer, more dynamic playing experience.

All test participants reported that the VSTi worked effectively within a composition, enhancing the synergy between instruments. The VSTi's flexibility also received positive feedback, with 80% of users noting its ability to allow improvisation in various musical contexts. Additionally, 75% of users found it easy to improvise with the VSTi, confirming its success in helping musicians explore their creativity. Post-production results further validated that the keroncong guitar VSTi not only performed well but also proved to be a highly valuable tool for musicians. Its quality, flexibility, and seamless integration in musical compositions make it a promising innovation in keroncong music education and practice.

Discussion

This study shows three core stages in making keroncong guitar VSTi, namely pre-production, production, and post-production. In the pre-production stage, the researchers collected data through observation of conventional keroncong music works. This step was fundamental as the basis for designing the right notation, which will be processed in the next process. This is in line with the view of Pratama & Latifah (2023) emphasizing that individuals in the music field can now utilize various software such as Kontakt libraries and DAWs to produce and learn music. This practice shows the recognition of the importance of technology in enriching the understanding and experience of learning music. As the results have been presented, keroncong guitar playing is done improvisationally with various improvisational ideas including the application of non-harmonic tones (Kusumah, 2021). For every educator or musician, improvising requires special abilities which are acquired through an understanding of the principles of improvisation (Hennekam, 2022). Hendriyana (2021) confirms that these stages can produce works and/or learning media.

Pre-production showed the prepared notations were transformed into audio of improvisational patterns playing on a keroncong guitar. The application of non-harmonic tones lay in the chromatic notes before the notes that became harmony in a chord. The melody movement is arranged in ascending and descending order to make it easier for VSTi users to arrange the keroncong guitar

playing based on the direction of the melody movement that follows the movement of the chord in a progression. The designed notation paid attention to the major and minor systems of a chord. Then, at the production stage, the realization of the notation into audio where the transformation process was carried out through the use of a guitar VSTi that is already available on the DAW by also adjusting the velocity to adjust the dynamics to make it feel more realistic and not monotonous. After that, the researchers exported the audio to obtain data in .wav format, which was mapped to the midi system through the Kontakt library. The final result was tested on the VSTi using DAW by creating a keroncong music composition to test that the VSTi can operate as intended.

The production stage involves the implementation of the designed notation into audio. By utilizing the guitar VSTi available in DAW, researchers can produce more dynamic playing patterns. Velocity settings in production aim to create a more realistic sound, while still maintaining the characteristic improvisation inherent in keroncong guitar playing. This is in line with the opinion of Cano et al., (2018) and Portowitz et al., (2014) revealing that the use of technology in music arts education must be considered by educators to create an optimal learning environment.

Next, the post-production stage includes the process of exporting audio and mapping in Kontakt Library, which serves to organize the playing pattern in a way that is easily accessible to users. This process did only increased the ease of use of VSTi but also contributed to efforts to preserve keroncong music in an educational context. This has a positive impact on the ability of educators to integrate technology into the curriculum, strengthening Swanwick (2001) argument regarding the relationship between music technology, cultural heritage, and music arts education that influence each other.

These steps have shown the process of making the keroncong guitar VSTi as a learning medium for keroncong music arrangement and also an audio reference to overcome the limitations of musicians in playing the keroncong guitar. In its use in learning media, technology in music arts education in general is something that is considered important to improve the quality of learning (Carlisle, 2013). DAW in its use has shown its capacity to accommodate the musical creativity of each individual. (Gorbunova & Govorova, 2018; Hidayat & Syafwandi, 2022; Pendergast, 2022).

Keroncong guitar VSTi can be integrated into the music curriculum at various levels of education. For example, in high school, music teachers can use this VSTi as a teaching tool for improvisation. Through practice sessions, students can practice playing keroncong guitar while applying the playing patterns that are available in the VSTi. In addition, another scenario is to hold a workshop where students work in groups to create keroncong music compositions using this VSTi, allowing them to collaborate and improvise directly. By implementing VSTi in various practices and activities, educators can provide a more interactive and creative learning experience, and encourage students to develop their improvisation skills in cultural traditions. This also creates space for more open musical exploration, where students can learn and adapt to various new styles and techniques. (Riyadi & Budiman, 2023).

The findings of this study support previous literature, which asserts that technological advances in music arts education enable educators to make significant innovations in learning (Frenki et al., 2018; Gunawan, 2023; Pratama & Latifah, 2023). Skills in using technology not only enrich the learning experience for students but also preserve and develop musical heritage for future generations. This initiative is expected to pave the way for further research in the context of developing virtual musical instruments that support music arts education more broadly.

CONCLUSION

The virtual instrument product of the keroncong guitar developed in this study addresses the rapid technological advancements in music education. VSTi not only serves as a tool for learning keroncong music but also as a reference for musicians in creating compositions. Consultations with keroncong music practitioners confirmed its usability, while also highlighting the need for further development to expand the variety of keroncong guitar patterns. The VSTi offers a practical solution for music educators, enhancing improvisation teaching methods and enabling a more interactive and engaging learning experience for students. Technological proficiency is now essential for educators

to provide innovative and relevant teaching, while creativity in designing technology-based learning tools is crucial for fostering innovation in music education. Also, the rise of diverse music applications opens opportunities not only for educators but also for musicians and composers to explore their creativity through technology.

This study encourages musicians to participate in developing music technology as a creative platform. Future research should explore additional guitar patterns and refine the user interface, enhancing the VSTi's support for music learning and practice. Identifying new advancements in music education technology will enrich the educational and creative experience for both educators and students. Thus, the keroncong guitar VSTi is more than an innovation; it is a catalyst for transformative changes in music education, paving the way for more effective and engaging learning in the future.

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Factor analysis of algebraic thinking skills: A case study on developing area model algebra worksheet based on PhET Interactive Simulation

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ABSTRACT

Algebraic thinking is a vital skill in mathematics education, enabling students to generalize patterns, decompose expressions, and apply mathematical models in real-world contexts. However, students often struggle to connect abstract algebraic concepts to practical, real-world problems, which limits their ability to apply these skills effectively. This study aims to uncover the latent structures underlying students' algebraic thinking skills through Exploratory Factor Analysis (EFA). Data were collected from 60 junior high school students in Serang, Banten, who completed worksheets assessing five indicators of algebraic thinking: X1 (Generalization – Decomposing an expression), X2 (Generalization – Using area model), X3 (Transformational – Representing multiplication problem), X4 (Transformational – Strategies for multi-digit numbers), and X5 (Meta-global level – Using area model in real-world contexts), alongside algebraic thinking ability scores (Y). Using varimax rotation, the analysis identified two significant factors. The first, "Generalization and Area Model Application Capability," explained 31.118% of the variance, with high loadings for X2 (0.701) and X3 (0.724). The second, "Transformational Strategies in Multi-digit Numbers," accounted for 20.543% of the variance, with strong loadings for X1 (0.923) and X4 (0.631). Together, these factors explained 51.661% of the total variance. These findings underscore the importance of enhancing generalization skills through area models, including their application to real-world problems and strengthening transformational strategies for multi-digit operations. Incorporating interactive tools like PhET simulations may further support these cognitive processes. Future research should explore classroom implementation and its impact on students' long-term outcomes.

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INTRODUCTION

In mathematics education, students at the junior high school and senior high school levels are expected to master algebraic thinking as a key competency, as it forms the foundation for more advanced mathematical reasoning and problem-solving (Newton et al., 2020; Kieran, 2022). Ideally, students should have a deep understanding of algebraic concepts and be able to apply mathematical

strategies to solve complex problems. Mastery of algebra includes the ability to recognize patterns, make generalizations, and understand symbolic representations and relationships between variables (Unal et al., 2023). Students with strong algebraic thinking skills can use their knowledge to solve various types of problems, from simple to those requiring higher-order thinking and creative problem-solving. If students lack strong algebraic thinking skills, they will face various academic and practical challenges (Sibgatullin et al., 2022). Academically, students struggling with algebra may find it difficult to grasp other subjects that require algebraic understanding, such as physics, chemistry, and economics (Turşucu et al., 2020). The inability to understand and use algebraic concepts can also hinder their problem-solving and critical-thinking skills, which are essential in various fields. Practically, lacking algebraic thinking skills can limit students' job opportunities, especially in professions requiring strong mathematical and analytical abilities (Huincahue et al., 2021). Additionally, algebraic thinking is crucial in everyday life, such as managing personal finances, understanding statistical data, and making informed decisions. Therefore, it is essential to develop and strengthen students' algebraic thinking skills through innovative and effective teaching approaches.

In reality, many students struggle to understand and apply algebraic concepts. Common errors include misinterpreting algebraic expressions, difficulties in generalizing patterns, and challenges in translating words into algebraic expressions or vice versa (Chea & Baba, 2021). Students also often struggle to develop and justify methods for using area models to determine the products of monomials and binomials, as well as to recognize that area represents the product of two numbers and is additive. These difficulties reflect a lack of deep understanding and fundamental skills necessary for mastering algebra (Osei & Agyei, 2024). Traditional, non-interactive teaching methods often leave students feeling bored and unmotivated (Hemmati et al., 2024). Limited learning aids and a lack of innovative teaching methods also hinder achieving the expected algebraic competencies. Many students can only memorize formulas without understanding the underlying concepts (Thompson & Harel, 2021). This lack of algebraic thinking skills results in students being unprepared for academic challenges in other subjects requiring algebraic understanding, such as physics and chemistry, and limits their job opportunities in fields requiring strong mathematical and analytical skills (Mathaba et al., 2024). This indicates a gap between curriculum expectations and classroom reality. Observations from a preliminary study conducted over two consecutive academic years with junior high school students in Serang, Banten, revealed that 65% of students in the target group struggled to generalize patterns or decompose algebraic expressions, while 58% faced significant difficulties in applying area models or translating word problems into algebraic forms. These findings support the notion that students in the study context experience similar challenges. Students do not receive learning experiences that support the development of critical and analytical thinking skills.

There is a significant gap between the ideal and actual conditions in algebra learning. Ideally, algebra teaching should involve the use of interactive technology and innovative teaching methods that support deep understanding and practical application of algebraic concepts (Villa-Ochoa & Suárez-Téllez, 2021). However, in reality, many schools still rely on traditional teaching methods that are less engaging and ineffective in developing students' algebraic thinking skills. Despite many studies showing the effectiveness of interactive simulations in mathematics learning, their implementation in the field remains limited. This is due to a lack of resources, teacher training, and institutional support needed to integrate interactive technology into the curriculum (Akram et al., 2022). The gap is also evident in the quality and content of worksheets used in algebra teaching. Existing worksheets often do not meet specific indicators necessary to comprehensively develop students' algebraic thinking skills (Uyen et al., 2021). Important indicators such as generalization through expression decomposition, the use of area models, representation of multiplication problems, strategies for multi-digit numbers, and the application of area models in real-world contexts are often not considered in worksheet development. As a result, students do not receive adequate learning experiences to build the critical and analytical thinking skills needed in algebra. To bridge this gap, there must be systematic efforts to develop and implement worksheets that meet all these important indicators. Additionally, the use of interactive simulations can be an effective solution to create a more engaging and profound learning environment (Campos et al., 2020). By visualizing abstract concepts and increasing student engagement, these simulations can help students better understand

and apply algebraic concepts (Ziatdinov & Valles, 2022). Furthermore, adequate teacher training and institutional support are crucial to ensure that interactive technology and innovative teaching methods can be effectively integrated into everyday teaching.

To bridge the gap between the ideal and actual conditions in algebra learning, the development of worksheets based on PhET interactive simulations that meet algebraic thinking skills indicators can be an extremely effective solution. PhET interactive simulations allow students to visualize algebraic concepts and conduct virtual experiments, supporting deep conceptual understanding (Chinaka, 2021; Oktaviyanthi & Sholahudin, 2023). These simulations provide a dynamic learning environment where students can actively explore abstract concepts such as algebraic expression decomposition and the use of area models, helping them develop transformational skills, integrate strategies for solving multi-digit problems, and apply area models in real-world contexts (Perkins, 2020). The use of factor analysis in this research helps rationally identify and confirm the key indicators that worksheets must meet to develop students' algebraic thinking skills (Oktaviyanthi & Agus, 2023). Factor analysis allows for the exploration of latent structures within the data and identifies the main factors that significantly contribute to students' algebraic thinking skills (Pitta-Pantazi et al., 2020). Using the results of this factor analysis, we can determine which worksheet items and indicators specifically aid in optimizing students' algebraic thinking abilities.

Recent research indicates that interactive simulations in mathematics education, particularly PhET-based ones, have great potential to enhance students' algebraic thinking skills (Engelbrecht & Borba, 2024; Llorella et al., 2024). These simulations enable students to visualize and interact with abstract concepts, thereby increasing their engagement and motivation to learn (Huang et al., 2022). Previous studies have shown that students who use interactive simulations demonstrate significant improvements in conceptual understanding and problem-solving skills compared to those who learn through conventional methods (Araiza-Alba et al., 2021). Moreover, the development of worksheets based on PhET interactive simulations can be an effective solution to help students better develop critical and analytical thinking skills, as well as improve their conceptual understanding and ability to apply algebraic concepts in various contexts (Agus & Oktaviyanthi, 2023). Furthermore, the use of factor analysis in this research provides deeper insights into the latent structure of students' algebraic thinking skills and helps identify the main dimensions of algebraic thinking measured through five specific indicators (Bianchi, 2020; Zhdanov et al., 2023). By understanding the complex structure of algebraic thinking data, more effective and focused learning strategies can be designed, allowing researchers to develop better assessment tools and educational interventions (Suherman & Vidákovich, 2022; Durkin et al., 2023). This research adds a new dimension to the development of mathematics education by integrating PhET-based interactive simulations into specially designed worksheets to enhance students' algebraic thinking skills. The novelty of this research lies in its comprehensive and data-driven approach to designing worksheets, which focuses not only on conceptual understanding but also on practical application through the use of interactive technology. Leveraging factor analysis, this research provides deep insights into the latent structure of algebraic thinking skills, aiding in designing more targeted and effective educational interventions.

METHOD

This study employed a quantitative approach using Exploratory Factor Analysis (EFA) with a primary focus on factor analysis aimed at identifying the latent structure of students' algebraic thinking skills based on five skill indicators measured through worksheet items (X1 to X5) and the algebraic thinking ability scores of the students (Y). This approach provides deep insights into the dimensions underlying algebraic thinking skills and how these variables are interrelated. The worksheet item indicators are detailed in Table 1.

Table 1. Description of Variables from Worksheet Items

No.	Worksheet Item	Variable Description	Variable
1	Generalization Indicator: Students can Decompose Algebraic Expressions, Including those Containing Variables	Generalization - Decomposing an Expression	X1

No.	Worksheet Item	Variable Description	Variable
2	Generalization Indicator: Students can Develop and Justify the Area Model Method to Determine Algebraic Multiplication Results	Generalization - Using an Area Model	X2
3	Transformational Indicator: Students can Represent a Multiplication Problem as the Area of a Rectangle	Transformational - Representing Multiplication Problem	X3
4	Transformational Indicator: Students can Develop and Justify Algebraic Multiplication Results as the Sum of Rectangular Areas	Transformational - Strategies for Multi-Digit Numbers	X4
5	Meta-Global Level Indicator: Students can use the Algebraic Area Model to Solve Real-World Problems	Meta-global level - using Area Model in Real-World Contexts	X5

Table 1 presents the five variables (X1 to X5) that represent different indicators of algebraic thinking skills, which were assessed through the worksheet items. This research model focuses on data analysis from 60 students who completed worksheets containing specific indicators of algebraic thinking skills. The study does not involve direct experimentation or intervention but centers on factor analysis to understand the internal structure of the data. The research model involves data collection encompassing scores on worksheet items (X1 to X5) and students' algebraic thinking ability scores (Y) for analysis using factor analysis techniques. Figure 1 is the methodology presented in a flowchart format, which visually outlines the key steps and processes involved in our research.

Figure 1 illustrates the research methodology flowchart, which outlines the systematic steps taken throughout the study. The study begins with data collection involving students' scores on five worksheet items (X1 to X5) and their algebraic thinking ability scores (Y). After data collection, the next step is data standardization to ensure uniformity in the analysis. Then, data suitability is tested using the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity to determine if the data is appropriate for factor analysis (Steenkamp & Maydeu-Livares, 2023). If the data meets the criteria, factor analysis is conducted to identify the number of relevant factors and the factor loading patterns (Morin et al., 2020).

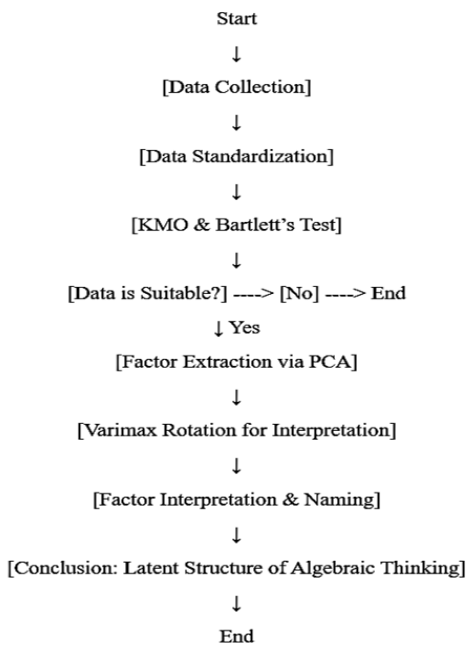

Figure 1. Research Methodology Flowchart

The main instrument in this study is the worksheet items that encompass algebraic thinking skill indicators. These worksheets consist of five key items that assess various aspects of algebraic thinking, such as generalization, transformation, and application of area models. Scores on these items, along with students' algebraic thinking ability scores, are used as data for factor analysis. The

data collection technique involves gathering scores from 60 junior high school students in Serang, Banten, and processing the data for analysis. Before participation, all students were informed about the purpose of the study, their voluntary involvement, and their right to withdraw at any time. They were given the option to accept or decline participation, and consent was obtained from those who agreed to participate.

The worksheets were distributed during regular class sessions. Clear instructions were provided to the students on how to complete the tasks, and they were given sufficient time to answer the questions. Assistance was available for clarification during the task completion. The collected data includes numerical values from the worksheet items and algebraic thinking ability scores that reflect students' performance in various aspects of algebraic thinking skills.

The data analysis technique used is Exploratory Factor Analysis (EFA), aimed at identifying the latent structure behind the measured variables (Sürücü et al., 2022; Rogers, 2022). Here is the process in more detail:

1. Data Standardization ensures that all scores are comparable by eliminating any biases due to differences in measurement scales.
2. Suitability Testing checks whether the data meets the requirements for factor analysis. If the KMO value is high (> 0.6), and Bartlett's Test is significant, the data is suitable for factor extraction.
3. Principal Component Analysis (PCA) is used to extract the factors. Each factor explains a certain percentage of variance in the data. Factors with eigenvalues greater than 1 are considered significant and are retained.
4. Varimax Rotation simplifies the interpretation by maximizing the loadings of each variable on one factor, making the results more interpretable.
5. Interpretation of Factors is based on the factor loadings. For instance, a variable with a high loading on a factor indicates a strong relationship with that factor, helping to name and define each factor (e.g., 'Generalization Skills' or 'Transformational Strategies').

RESULTS AND DISCUSSION

Results

Data Suitability Testing

The suitability and adequacy of the data for factor analysis were assessed using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity. The KMO value ranges from 0 to 1 with the following interpretation:

Table 2. KMO and Bartlett Test Decision Criteria

No.	KMO Test		
	KMO Value	**Value Interpretation**	**Decision**
1	0.90 to 1.00	Very Good Adequate	• If KMO > 0.60, the Data is Adequate for Factor Analysis. • If KMO < 0.60, the Data is Inadequate for Factor Analysis.
2	0.80 to 0.89	Good Adequate	
3	0.70 to 0.79	Adequate	
4	0.60 to 0.69	Marginal	
5	0.50 to 0.59	Inadequate	
6	< 0.50	Very Inadequate	
Bartlett Test			
Bartlett's Test Decision Criteria			
• If p-value < 0.05, the null hypothesis is Rejected, Indicating that the Correlation Matrix is not an Identity Matrix and the Data is Adequate for Factor Analysis. • If p-value > 0.05, the null Hypothesis is not Rejected, Indicating that the Correlation Matrix is an Identity Matrix and the Data is Inadequate for Factor Analysis.			

Table 2 presents the decision criteria for the KMO and Bartlett tests. It outlines the KMO value interpretation, indicating data adequacy for factor analysis, and provides the p-value criteria for Bartlett's test, which assesses whether the correlation matrix is suitable for analysis.

Using IBM SPSS Statistics version 21, the KMO and Bartlett's Test of Sphericity results are shown in Table 3.

Table 3. KMO and Bartlett's Test for 5 Variables

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.872
Bartlett's Test of Sphericity	Approx. Chi-Square	465.650
	df	10
	Sig.	.001

From Table 3, the KMO value is 0.872, which falls in the range of 0.80 to 0.89, interpreted as good. This indicates that the data is suitable for factor analysis. The significance value of Bartlett's Test is 0.001 < 0.05, leading to the conclusion that the correlation matrix is not an identity matrix, thus the data is adequate for factor analysis.

Next to the MSA test, it evaluates the adequacy of the sample for each variable individually. The decision criteria for MSA are as follows if MSA > 0.60, the variable is considered adequate for inclusion in the factor analysis, and if MSA < 0.60, the variable is considered inadequate for inclusion in the factor analysis and should be excluded.

Table 4. Measures of Sampling Adequacy

		X1	X2	X3	X4	X5
Anti-image Correlation	X1	.876[a]	-.260	-.525	-.343	-.093
	X2	-.260	.836[a]	-.482	-.247	-.547
	X3	-.525	-.482	.845[a]	.065	.270
	X4	-.343	-.247	.065	.942[a]	.046
	X5	-.093	-.547	.270	.046	.872[a]

a. Measures of Sampling Adequacy(MSA)

Based on Table 4, the MSA values for X1 (0.876), X2 (0.836), X3 (0.845), X4 (0.942), and X5 (0.872) are all greater than 0.60, indicating that the variables have adequate sample sizes and are suitable for inclusion in the factor analysis.

Factor Extraction (Including Number of Factors)

Factor extraction determines the number of factors that adequately explain the underlying data structure. This process involves several steps and decisions based on various criteria and statistical methods.

Kaiser Criterion (Eigenvalue > 1)

Factors with eigenvalues greater than 1 are considered significant and retained in the model. The SPSS output showing eigenvalues is presented in Table 5.

Table 5. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.556	31.118	31.118	1.556	31.118	31.118	1.529	30.588	30.588
2	1.027	20.543	51.662	1.027	20.543	51.662	1.054	21.074	51.662
3	.925	18.503	70.165						
4	.812	16.248	86.413						
5	.679	13.587	100.000						

Extraction Method: Principal Component Analysis.

Table 5 outlines the eigenvalues and percentage of variance explained by each factor. Factor 1, with an eigenvalue of 1.556, explains 31.118% of the total variance, while Factor 2, with an eigenvalue of 1.027, accounts for 20.543% of the variance. Together, these two factors explain 51.661% of the variance, meaning that more than half of the variability in students' algebraic thinking skills can be explained by these two factors. The remaining factors are not retained, as their

eigenvalues are below 1, indicating that they do not significantly contribute to explaining the variance.

Scree Plot

A scree plot displays the eigenvalues of factors in descending order. Significant factors typically lie before the "elbow" point (a sharp change) in the plot, while factors after the elbow point are considered insignificant as they explain little additional variance.

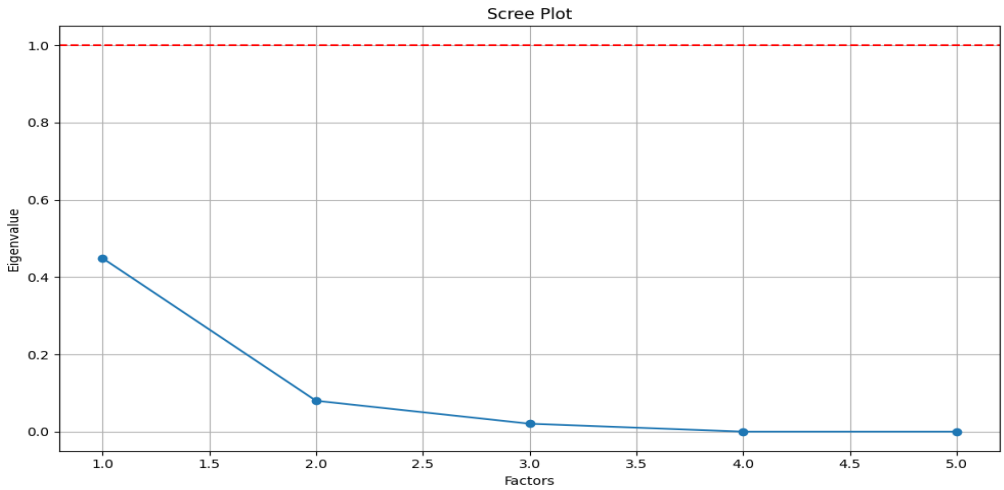

Figure 2. Scree Plot of Significant Factors

Figure 2 displays the Scree Plot, which helps to determine the number of significant factors to retain. The elbow joint is observed after Factor 2, indicating that only two factors should be retained for further analysis. This visual representation supports the decision made in Table 5 to retain two factors with eigenvalues greater than 1. Factors beyond this point (factors 3, 4, and 5) explain diminishing variance and are not considered significant for this study.

Communalities (> 0.5)

An additional criterion for determining significant factors is the communality values of variables. Communalities measure the proportion of variance in each variable explained by the extracted factors. Communalities > 0.5 indicate that the variable is well-explained by the extracted factors.

Table 6. Variable Communalities

	Initial	Extraction
X1	1.000	.867
X2	1.000	.794
X3	1.000	.725
X4	1.000	.646
X5	1.000	.454

Extraction Method: Principal Component Analysis.

Table 6 presents the commonalities for each variable, which indicate the proportion of variance in each variable that is explained by the retained factors. For instance, X1 has a commonality of 0.865, meaning that 86.5% of the variance in the ability to decompose expressions is explained by the two factors. Similarly, X2 (Generalization using the area model) has a commonality of 0.794, showing that the area model application skill is well-represented by the factors. Communalities greater than 0.5 suggest that the variables are well-explained by the factor model, indicating that the retained factors adequately capture the underlying structure of the data.

Based on the criteria and methods above, the factor extraction decision is to retain two factors: **Factor 1**: Combines X2 and X3, related to generalization and area model application capability. **Factor 2**: Combines X1 and X4, related to the decomposition of expression and transformational strategies in multi-digit numbers.

These factors sufficiently explain the data variance and provide a clear understanding of the latent structure of students' algebraic thinking skills measured by the provided worksheets. Communalities > 0.5 show that the variables in these factors are well-explained by the extracted factors.

Factor Rotation (Loading Factor)

After factor extraction, factor rotation is performed to enhance interpretability. The goal of factor rotation is to achieve a clearer loading pattern, where each variable has a high loading on one factor and low loadings on other factors, simplifying interpretation. Loading factors are evaluated to determine which variables have high loadings on each factor. Variables with loading factors > 0.5 on one factor are considered significant. The factor rotation in the SPSS output using varimax rotation is presented in Table 7.

Table 7. Varimax Factor Rotation

	Component	
	1	**2**
X1	.112	.923
X2	.701	-.048
X3	.724	-.029
X4	-.510	.631
X5	-.491	-.112

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Table 7 shows the results of the varimax rotation, which simplifies the interpretation of factor loadings. The table presents the loadings of each variable on the two identified factors. X2 (0.701) and X3 (0.724) load strongly on Factor 1, indicating that this factor represents the Generalization and Area Model Application Capability. On the other hand, X1 (0.923) and X4 (0.631) load heavily on Factor 2, representing Transformational Strategies in Multi-digit Numbers. The loadings make it clear which variables are most strongly associated with each factor, and how these variables contribute to the cognitive structures being analyzed in the study.

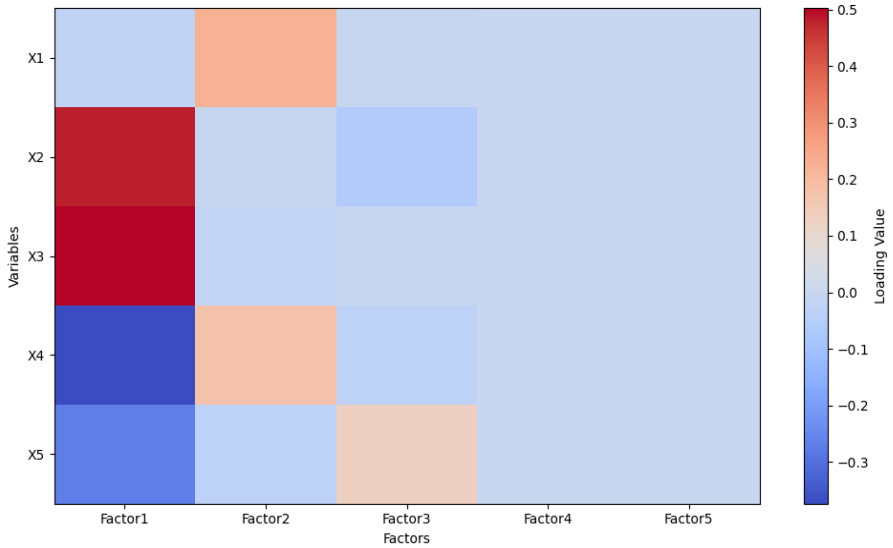

Figure 3. Factor Loadings Visualization

Figure 3 visually represents the factor loadings of the variables on the two identified factors. The darker areas in the plot correspond to higher loadings, highlighting the variables that contribute most to each factor. For example, X2 and X3 show strong associations with Factor 1, while X1 and X4 are closely linked to Factor 2. This visual aid helps to quickly interpret the relationships between variables and factors, making it easier to see how the underlying cognitive skills are grouped in the analysis.

Factor Interpretation and Naming

Based on the analysis and factor rotation results, the following is the interpretation and naming of the factors:

Factor 1: Generalization and Area Model Application Capability. This factor consists of X2 (Generalization - Using area model) with a loading of 0.701 and X3 (Transformational - Representing multiplication problem) with a loading of 0.724, explaining 31.118% of the variance. This factor reflects students' ability to use area models in generalization contexts and represent multiplication problems, indicating the application of area models in generalization and transformational skills.

Factor 2: Transformational Strategies in Multi-digit Numbers. This factor consists of X1 (Generalization - Decomposing an expression) with a loading of 0.923 and X4 (Transformational - Strategies for multi-digit numbers) with a loading of 0.631, explaining 20.543% of the variance. This factor reflects students' ability to decompose algebraic expressions and use strategies for multi-digit operations, indicating a focus on transformational strategies in multi-digit contexts.

To ensure that the formed factors have no further correlation among themselves, it is necessary to trace the values in the component transformation matrix presented in Table 8. If the correlation values for each factor in the main diagonal lie in the range of 0.8 to 0.9, it indicates that the factors are not further correlated and fall into the category of very strong correlation.

Table 8. Component Transformation Matrix

Component	1	2
1	.975	-.224
2	.224	.975

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Table 8 provides the component transformation matrix, which helps to confirm the precision of the factor rotation. The values on the diagonal (both 0.975) indicate that the factors are well-formed and not further correlated. This confirms the independence of the two factors, reinforcing the validity of the factor rotation and the distinctiveness of the cognitive skills measured by each factor.

Discussion

Factor 1: Generalization and Area Model Application Capability

Factor 1 captures students' abilities to generalize algebraic concepts using area models. This factor includes variables related to the use of area models to represent and solve algebraic problems, specifically focusing on how students can abstract general patterns from specific cases. The high loadings of X2 (Generalization - Using area model, 0.701) and X3 (Transformational - Representing multiplication problem, 0.724) suggest that students who perform well on these items demonstrate a strong capacity to visualize algebraic relationships spatially. The ability to apply area models plays a pivotal role in understanding more abstract mathematical concepts. Area models help students connect geometric representations to algebraic expressions, bridging concrete visual experiences with symbolic reasoning. This process of generalization is crucial in developing algebraic thinking, as it allows students to see the broader application of a mathematical principle across different contexts (Kieran, 2022; Ünal et al., 2023). For example, a student who can use an area model to represent multiplication problems is not only solving the immediate problem but also developing an understanding of how algebraic expressions can represent real-world quantities and relationships.

Research supports the idea that visual models, such as area models, are essential tools for helping students move from concrete arithmetic understanding to abstract algebraic reasoning.

Studies by Hawes et al., (2022) suggest that spatial reasoning, facilitated by visual tools like area models, enhances students' ability to generalize mathematical concepts, which is critical for success in algebra. Furthermore, the work of Ellis et al., (2022) emphasizes the importance of generalization in developing higher-order mathematical thinking, as it enables students to recognize patterns, make predictions, and apply mathematical reasoning across various problem types. Thus, the identification of this factor highlights a key cognitive skill—generalization through the application of area models—that is foundational to algebraic competence. Instructional strategies that emphasize the use of visual models can be effective in strengthening this ability, as they provide students with concrete ways to explore and manipulate algebraic expressions, making abstract concepts more accessible.

Factor 2: Transformational Strategies in Multi-digit Numbers

The second factor, which explains 20.543% of the variance, is defined by high loadings on X1 (Generalization - Decomposing an expression, 0.923) and X4 (Transformational - Strategies for multi-digit numbers, 0.631). This factor represents students' abilities to decompose algebraic expressions and apply transformational strategies for multi-digit operations. These skills are essential for developing algebraic thinking (Findell et al., 2001). Decomposing algebraic expressions requires breaking down complex expressions into simpler parts for further manipulation, a higher-order cognitive skill critical in algebra (Spiller et al., 2023). Likewise, transformational strategies enable students to solve large-scale problems by applying efficient methods such as factoring or breaking down numbers into smaller components. Mastery of these skills helps students approach algebraic problems more flexibly and efficiently.

The varimax rotation method used in the factor analysis resulted in two independent factors, confirming that the first factor is related to generalization and area model application, while the second focuses on transformational strategies for multi-digit numbers. The independence of these factors is confirmed by a main diagonal correlation of 0.975. According to West (2021), transformational strategies are crucial for a deeper understanding of algebraic concepts, and students who can apply these strategies are better prepared for more complex algebraic tasks. Similarly, Dröse & Prediger (2023) found that the ability to decompose multi-digit operations is closely linked to algebraic success. These findings highlight the importance of educational interventions that emphasize not just basic algebraic operations but also transformational strategies to build a strong foundation for advanced algebraic reasoning.

While the two factors identified explain a significant portion of the variance in students' algebraic thinking, accounting for 51.661% of the total variance, there remains a 48.39% unexplained variance. This suggests that other factors, not captured by the current model, could also play a role in shaping students' algebraic thinking abilities. Possible influences include students' prior mathematical knowledge, individual differences in cognitive ability, and instructional variables that were not explicitly measured in this study. For instance, factors such as the quality of teaching, classroom environment, or students' motivational levels may contribute to the unexplained variance. These elements could have an impact on student's performance but were not part of the scope of this analysis. Additionally, the relatively low loadings of some items, such as X5 (using area models in real-world contexts), indicate that these variables might require further refinement or additional factors to explain students' algebraic thinking more comprehensively (Krawitz et al., 2022). These results highlight the need for further research to investigate the full range of cognitive and external factors influencing algebraic thinking skills.

The findings from this study are consistent with previous research emphasizing the importance of area models in teaching mathematics to foster skills in generalization and multiplication problem representation (Goldin, 2020; Lischka & Stephens, 2020). In addition, the ability to decompose expressions and use strategies for multi-digit numbers is recognized as a key component in developing students' algebraic thinking (Ortiz-Laso & Diego-Mantecón, 2020; Dröse & Prediger, 2023). These results reinforce the critical role that visual models and transformational strategies play in enhancing students' conceptual understanding of algebra. To address the primary research question, which aimed to uncover the cognitive structures underlying students' algebraic thinking, Exploratory Factor Analysis (EFA) identified two significant factors. Factor 1, Generalization and Area Model Application Capability, and Factor 2, Transformational Strategies in Multi-digit

Numbers, both represent distinct cognitive dimensions that are fundamental to algebraic thinking. These findings suggest that effective algebra instruction should emphasize the use of visual tools like area models to aid generalization and encourage the use of transformational strategies to handle complex, multi-digit problems. Both factors are supported by strong loadings, indicating that these skills are crucial for the development of algebraic proficiency.

The study's identification of two key cognitive factors has important implications for teaching and learning algebra. Factor 1, which emphasizes generalization through area models, points to the necessity of incorporating visual and spatial reasoning tools in mathematics curricula. Generalization is crucial in algebra as it allows students to recognize patterns and make predictions (Ureña et al., 2024). Providing students with opportunities to engage with area models can facilitate their transition from concrete arithmetic to abstract algebraic reasoning (Alam & Mohanty, 2024). Factor 2, which highlights transformational strategies in multi-digit numbers, emphasizes the importance of teaching students how to decompose complex algebraic expressions and apply strategies to simplify them (Whitacre & Rumsey, 2020). These skills are essential for higher-order problem-solving in algebra (Ortiz-Laso & Diego-Mantecón, 2020). Instructional interventions should focus on explicit instruction in decomposition, factoring, and simplification techniques, which will equip students with the tools necessary to tackle more advanced algebraic tasks. By addressing both factors, educators can help students build a robust foundation in algebraic thinking, enhancing their problem-solving abilities and overall mathematical competency. Moreover, integrating interactive tools like PhET simulations could further support these cognitive processes by providing dynamic, hands-on experiences that reinforce both generalization and transformational strategies.

Several recommendations arise from this study. First, the mathematics curriculum should incorporate the use of area models and transformational strategies to support the development of students' algebraic thinking. Second, teacher training should be enhanced to adopt teaching methods that effectively utilize physical manipulatives and real-world contexts to help students grasp complex mathematical concepts. Furthermore, the development of instructional materials that emphasize the use of area models and transformational strategies should be prioritized to provide relevant practice and examples for students. Further research is needed to test the effectiveness of this approach and provide deeper insights into how students' algebraic thinking skills develop over time. This study reinforces previous findings, provides strong empirical evidence on the structure of students' algebraic thinking abilities, and adds to the existing literature in mathematics education.

CONCLUSION

This study offers a novel contribution to the field of algebra education by revealing the latent cognitive structures underlying students' algebraic thinking skills. Through factor analysis, two key factors were identified: Generalization and Area Model Application Capability and Transformational Strategies in Multi-digit Numbers. These findings provide a deeper understanding of how students approach and solve algebraic problems, demonstrating that both visual representations and transformational problem-solving strategies are critical to enhancing algebraic competency. The innovative use of PhET interactive simulations further strengthens these insights by offering a dynamic, hands-on learning environment that aligns with the push for technology integration in education. The simulations provide a unique opportunity for students to visualize abstract concepts, reinforcing the need for such tools in modern classrooms. The identification of these two cognitive factors, which explain over 50% of the variance in student responses, underscores the foundational role of visual models and transformational strategies in algebraic success. Students who can generalize through visual aids and apply transformational techniques to multi-digit problems exhibit stronger algebraic proficiency. These results confirm the critical nature of these skills, offering educators a clear path for enhancing their instructional methods. Several recommendations emerge from these findings. Teachers should prioritize the use of visual models, such as area models, to help students generalize algebraic concepts and connect geometric representations with algebraic reasoning. Strengthening students' transformational strategies, like decomposition and multi-digit problem-solving techniques, is equally important in improving their flexibility in tackling complex

algebraic tasks. Additionally, integrating interactive simulations like PhET into classroom instruction can significantly enhance student engagement and deepen their understanding of abstract algebraic ideas. While the study has offered valuable insights, further research is needed to examine how students' algebraic thinking evolves, particularly their generalization and transformational abilities. Future studies should also assess the long-term impact of visual models and simulations across diverse student populations. Lastly, exploring how these cognitive structures transfer to other areas of mathematics or science could provide further insight into problem-solving skill development across disciplines. In conclusion, by focusing on generalization through visual tools and strengthening transformational strategies, educators can better support students in developing a deeper, more flexible understanding of algebra.

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Redesign of the science interpretation laboratory application (Labtafsin 2.0) using 3 languages as supporting media for science learning based on Al-Qur'an interpretation

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ABSTRACT

The application of the Science Interpretation Laboratory, as a learning media for the development of science interpretation science that leads to an Islamic worldview, faces practical obstacles by often experiencing errors (force close) in its use. This study aims to evaluate and redesign the Science Interpretation Laboratory Application to overcome these obstacles. With the stages of research (Waterfall System Development Life Cycle) SDLC has five stages: Requirements analysis, System and software design, Integration and system testing, and operation and maintenance. Then the application was tested with 2 material and media experts and 38 students. The results show that the redesign of the Labtafsin 2.0 application was successful, adding 3 language features (Arabic, English, and Indonesian). The functionality test (black box) results show that the application runs smoothly and can be used optimally on Android version 10. Ratings from material experts give an average of 94%, indicating that this app is suitable as a learning resource. Ratings from media experts give an average of 90%, the application is rated as very satisfactory. Then the assessment from students showed a score of 93%, and this application can be used very well. Further, it is necessary to develop, by adding video and quiz features according to the material to support learning.

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INTRODUCTION

The development of technology has made the form of learning increasingly dynamic so today's learning media has also led to the use of technology because the use of technology has become a necessity in everyday life, especially the use of smartphones (Susilo & Prasetyo, 2020). Among the learning concepts that use smartphone technology is mobile learning, which is a process of transferring information from smartphones to the hands of individual students through a base system, namely the operating system, the operating system which connects the application with the hardware, so that users can do everything according to their function in the application (Amirullah & Hardinata, 2017). Using mobile learning will form interactions and create new learning methods, because using new technology will form a learning system on a broad and varied scale (Sari & Ma'rifah, 2020),

among The varied forms of learning systems with mobile learning is the laboratory form. Digitized or virtual laboratory.

The first virtual laboratory was introduced in 1997 with the title Virtual Physiology Laboratory, the virtual laboratory itself includes experiments called objects from a dependent domain which are simulation programs, that include data files, tools that operate on objects, or reference books (Nirwana, 2016). Online labs, on the other hand, offer a wealth of opportunities for carrying out scientific research. Furthermore, one of the most recent pedagogical developments in the educational setting over the past few years has been the use of online experiments. Additionally, in addition to increasing educational opportunities for more students, they have been adapted to science education as an effective tool for improving learning quality and teaching methodologies, improving learning experiences, and raising student participation and motivation (Kharki et al., 2021). To fulfill this requirement, current best practices from the field of web user interface design should be used, and many software components can be used (Budai & Kuczmann, 2018).

The use of electronic technology which includes web-based, computer-based learning, virtual, and digital learning that takes place via internet channels, network systems, or without a network using electronic technology for learning is called E-learning. Then E-learning experienced development with the rapid development of wireless technology and various mobile devices from electronic online learning (E-Learning) to Mobile Learning (M-Learning) (Abdullah et al., 2021). Mobile learning refers to the use of mobile or wireless devices with the aim of learning that can be done anywhere (Alam & Mohanty, 2023). Mobile learning is the fourth revolution in educational development the previous revolution included the invention of writing, the use of textbooks in schools after the invention of the printing press, the emergence of mainstream education, and the fourth revolution was the use of e-learning technology and m-learning is part of e-learning where devices The mobile uses audio, visual, cognitive, cooperative and interactive through the use of smartphone devices to create direct and dynamic learning environments that are sustainable and not limited by space and time boundaries which lead to the elimination of traditional classes, routines, and imitations (Abdullah et al., 2021). The potential and prospects for the future development of mobile learning are very wide open considering the trend of an increasingly dynamic and mobile society as well as the demand for quality and diverse educational needs (Warsita, 2010).

The use of mobile learning as a learning medium in the Department Al-Quran and Tafsir Studies at Universitas Darussalam Gontor in the Basic Natural Sciences course and the Scientific Interpretation course, both courses explain the relationship between the verses of the Qur'an and its interpretation and science. Scientific interpretation is built on the assumption that the Al-Qur'an contains various kinds of knowledge, both discovered and undiscovered. This science departs from the paradigm that the Qur'an does not conflict with common sense and other sciences. The Qur'an itself contains other knowledge, not only of religious sciences, but also of political sciences, economics, and theoretical scientific knowledge contained therein (Puspitasari et al., 2020). so that the wonders of the Qur'an will be seen which are linked to the realities of contemporary life and make the Qur'an suitable for use at any time and place. Therefore, scientific discourse is needed as a link between science and the Qur'an, namely with *tafsir ilmy*.

Tafsir Ilmy is a science that interprets the verses of the Al-Qur'an with a scientific approach and explores the content of the Al-Qur'an based on scientific theories (Mustikasari & Badrun, 2021). An attempt to understand the verses of the Qur'an with *Isyarah Ilmiyah* from the perspective of modern science (Habibullah et al., 2024). Because the Qur'an is the source of all knowledge, research, and attention of Muslims are needed so that humans think about the greatness of the Qur'an, many verses of the Qur'an encourage humans to think, understand, and research the creation of Allah SWT. (Rifaannudin & Alauddin, 2022). There are more than 1000 verses that contain concrete verses and hundreds of others are related to universal phenomena (Rifanudin & Munandar, 2021), So this *Tafsir Ilmy* is the interpretation of ulama, scholars in looking at cosmic verses related to various scientific events using a scientific approach.

So a mobile e-based science interpretation laboratory was developed to help students get to know *Kauniyah* verses as a modern learning medium (Puspitasari et al., 2021). By making the smartphone a device for explaining scientific interpretation. One proof of the miracle of the Qur'an

is that it has verses on law, *muamalat*, and the science of *aqidah* which are a guide for humans in this world to know the Creator, every Muslim believes in everything created by Him, including faith with The day of resurrection and retribution will thus be depicted with grace, patience for Muslims and the wisdom of everything (Muthi'ah, 2019). In the *Kauniyyah* verses there is an indication of His majesty and power in this world. Thus, not all people understand and understand the existence of *kauniyyah* verses. In this case, the researcher wants to design an application regarding understanding the meaning of the Al-Qur'an and science.

The State of Art of this research draws from the results of previous research on the Preliminary Study of the Development of Mobile Learning in the Science Interpretation Laboratory (Labtafsin) which obtained the results that the study of the development of m-learning in the science interpretation laboratory needs to pay attention to the curriculum that will be implemented, and the form of m-learning as a description of the laboratory concept that will be developed (Puspitasari et al., 2020). Apart from that, further research into the effectiveness of Labtafsin 1.0 as a learning medium showed that the mobile learning science interpretation laboratory (Labtafsin Apps) took the form of an application on Android to help users access know kauniyah verses with explanations of scientific interpretations, as well as to increase interest in studying natural phenomena in perspective. Islam, the final result of the validity of the Science Interpretation Laboratory's M-learning is that regarding mobile learning it is in the good category, with a score of 4.5 from material and media experts, and a score of 4.4 from schoolgirl. The increase in pre-test and post-test results was 6 points, showing the results of testing the feasibility of application products on several students using a questionnaire and obtained an average score of 87.25%. Field trials based on material expert assessments and trials were 86.25% in the very feasible category. Therefore, it can be interpreted that in developing the mobile learning platform in the Tafsir Ilmy course, it is very suitable to be used as a learning media (Puspitasari et al., 2021).

Other research about mobile learning to support learning Tafsir Hadith shows the results that the product feasibility test based on the assessment of material experts and media experts obtained a percentage of 84.16% and 83.33% in the feasible category. Then the results of limited trials obtained a feasibility percentage of 81.61% and field trials of 88.33% in the very feasible category. Therefore, it can be concluded that the development of a mobile learning platform in the Tafsir Hadith course is very suitable to be used as a learning supplement (Ramadhan & Hamdan, 2022).

The Science Interpretation Laboratory application edition 1.0 could previously be downloaded on Playstore, but in 2023 the application experienced an error (force close). Then there is a need for evaluation and rework to overcome these obstacles. Researchers found an error in the hosted material database which could not be accessed again. One of the respondents from the Playstore of this application, explained that "this application experienced an error when changing the language. With this, you have to overcome errors that occur in the application". Apart from that, the languages used are still Indonesian and English, and there is no Arabic in the material, so it is necessary to perfect the previous application.

Then, in designing the Tafsir Sais Laboratory application, edition 2.0, researchers added three languages, namely Indonesian, English, and Arabic, by re-creating this application so that it would experience changes in terms of appearance, features, and additional language material. This application has the potential to be an effective and efficient learning tool in studying scientific interpretation and has a correlation with modern knowledge.

METHOD

This research was conducted on the campus of Universitas Darussalam Gontor. The research object is the student's Department Al-Qur'an and Tafsir Studies, with the population used by students in semesters 4, 6, and 8 in the study program and 2 experts in material and media. The database used for this application uses Firebase provided by Google. The application design method in this research uses the Waterfall System Development Life Cycle (SDLC) method. This method develops systematic software and also sequential and continuous stages of the method (Purnia et al., 2019). Development of the system used for this research. The SDLC method has five main stages in its

development, namely Requirement Analysis, Design, Coding, Testing, and Maintenance. The stages of the SDLC method are depicted in Figure 1.

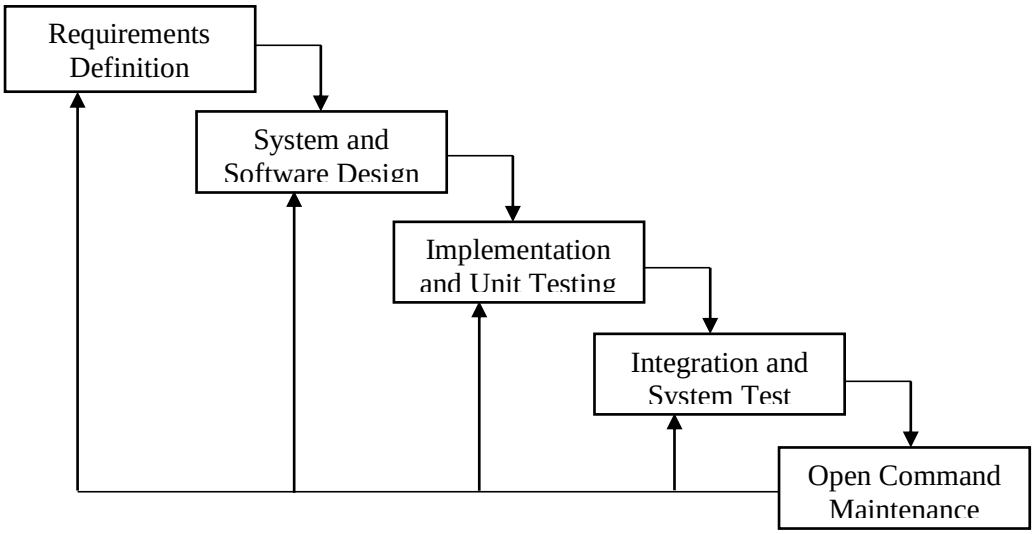

Figure 1. Methodology Stages of SDLC

1. Requirements Analysis
   Constraints are analyzed and applied to the results of consultations with users, then defined in detail and with more specifications in the system (Muhlisah, 2017). This identification stage is the stage of exploring and formulating the problem until the technological solutions used in the development of this learning media are then assembled and summarized. At this stage, initial planning is carried out regarding the completion of the force close and the development of the use of three languages. This design will be directed at improving the quality of learning by targeting an increased understanding of the material through the use of more inclusive language.
2. System and Software Design
   The design stage aims to meet the needs of the software system by forming the design or architecture. The formation of this system is the basis for describing the system equipment in its development, including Figure 2.
   a) Use Case Diagram
      The user actors in this application system are students or lecturers. When you first enter the application, you must log in to register first. After logging in, the user enters the home page on this display and can select the favorite icon and material. In the favorite display, the user can determine favorites on the material they like. For the material display, they can select the title and explanation studied in the application.

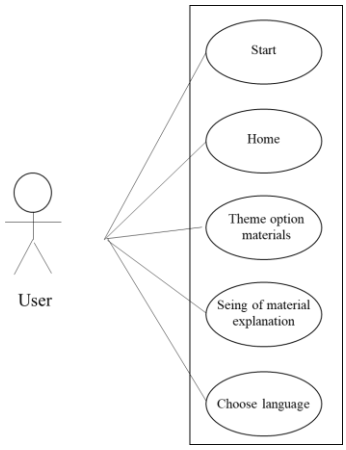

Figure 2. Use Case Diagram

b) Activity Diagram

Diagram activity modeling a workflow sequence of a process described in Figure 3. The Diagram Activity in Figure 3 displays a user page that will direct you to the home page and then on the home page there are several language and material options. After selecting some of the material that has been presented, then enter the content of the material that can be studied on the detail page.

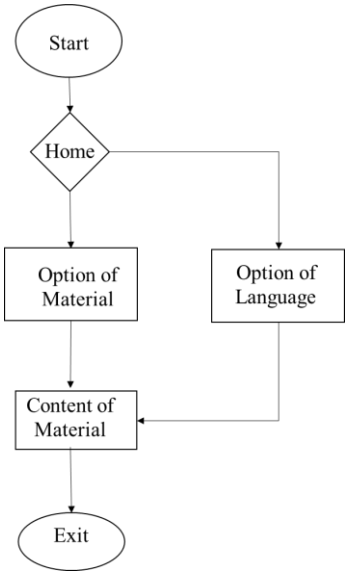

Figure 3. Activity Diagram

a) Use Case Database

The Database Usecase above in Figure 4 illustrates the workflow of the "Science Interpretation Laboratory" application, which is focused on users who want to access scientific materials. In addition to language options, there is material displayed with 12 choices of material to be studied in it. Of the 12 materials, namely: Astronomy, Botany, Embryology, Physiology, Geology, Animals, Hydrology, Medicine, Marine Affairs, General Knowledge, Biology, and Physics.

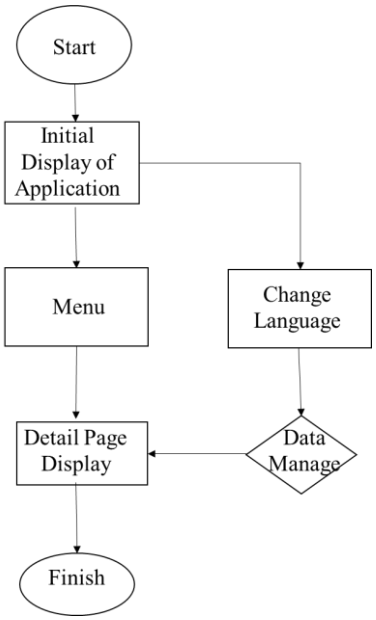

Figure 4. Use Case Database

3. Integration and Unit Testing
   The next stage, designing software involves verification testing to fulfill software requirements. This stage aims to explain the details or description of the components that will be used and help see what was needed previously at the program creation stage.
4. Integration and System Testing
   Features and programs are combined and tested to ensure whether they meet the requirements of the software or not. And after testing, the software can be sent to customers or published. This testing stage will be carried out after the Science Interpretation Laboratory application is completed. This research will carry out several tests such as:
   a) Testing Blackbox
      This test is carried out to test several aspects of the system, by looking at and paying attention to the internal logic structure of the software. The results of this test will provide if the input and output produced are adjusted to the system created. This application testing system is built from the conditions for success in every case where the software test is successful and doesn't fulfill the category.
   b) Testing Hardware
      In this test, several hardware or smartphones with different brands and specifications will be tested to see whether the application runs smoothly or not.

RESULTS AND DISCUSSION

Results

It was revealed that the Science Interpretation Laboratory Application could previously be downloaded via Playstore. However, in 2023 the use of this application will be hampered by significant technical problems, that errors or force closes. The existence of this problem indicates the need for in-depth evaluation and rebuilding of the application to overcome this problem. During the research, researchers discovered that the main obstacle lay in the material database which couldn't be accessed again, affecting the availability and accessibility of the material for users.

Design Stage

At this stage, the ideas obtained in the previous stage will be implemented into an application that can be used on several mobile devices. The redesign can be seen in Figure 5 below.

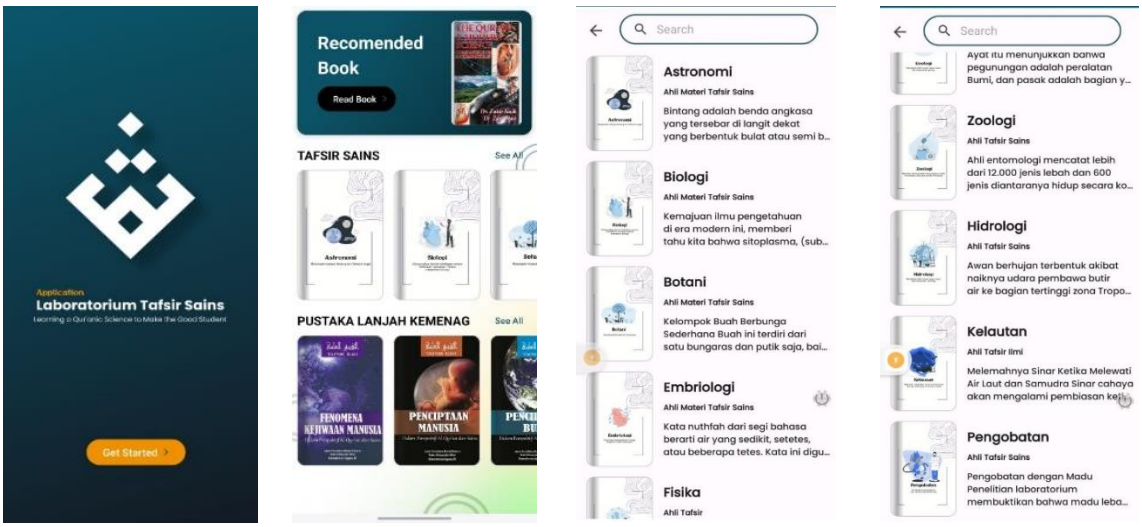

Figure 5. Main View

As seen in Figure 5, the Science Interpretation Laboratory application has undergone a logo change by including an Arabic Kufic style logo so that it looks like it symbolizes strength and firmness in adhering to principles and beliefs.

You can see changes when this application is opened, then the main display has a Get Started button, when this button is pressed it will go to the page menu. The structure that has changed is the choice of Arabic, Indonesian, and English, and the material presented is: Astronomy, Botany, Embryology, Physiology, Geology, Animals, Hydrology, Medicine, Marine Affairs, General Knowledge, Biology, Physics.

Figure 6. Details Page

Then in Figure 6, the Details Page presents detailed information on each material. Through the Reading View, this application provides an interactive learning experience with material explanations, arguments, and image visualization to facilitate users' understanding of science interpretation material. Thus, it is hoped that the Science Interpretation Laboratory Application can become an effective learning tool and support students' understanding of science interpretation concepts.

Figure 7. Content Page

On this page, users can view and read the contents of the selected material. The material page in this view can be found on the material page Shows the display of material content selected by the user. This page is designed to present the content clearly and easily to read, providing a comfortable and informative reading experience.

In addition to the scientific interpretation explanations provided, the Labtafsin 2.0 application is also supported by references that can be read directly from the reading source, namely from the following books.

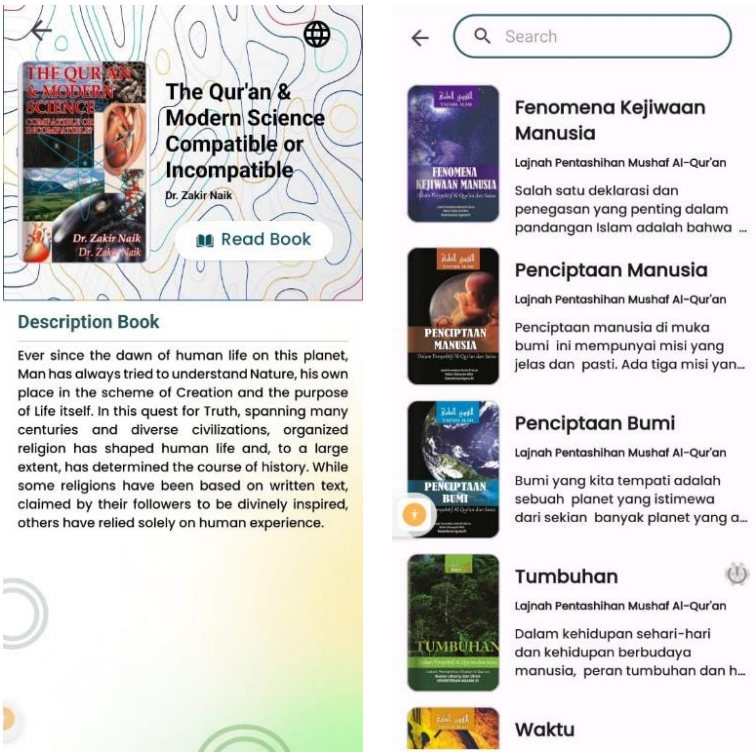

Figure 8. Book View

If you look at this application, it supports being used for wider knowledge, that is, it is not limited to the data contained in the application, but also the availability of books will make it easier for readers to refer directly to the knowledge which is explained more broadly and in detail, while for short data and In general, this application is sufficient to provide information related to scientific interpretation in several themes.

Implementation Stage

Then the next step is the testing stage for the Science Interpretation Laboratory application (Labtafsin 2.0). Before this application is used by all users, we have designed and carried out a series of testing stages, as explained in the previous chapter. This is an important step to ensure the application works well and is ready to be used by all users later. Researchers conducted experiments on 38 student respondents and 2 respondents from material and media experts to see the results obtained from the Labtafsin 2.0 application experiment.

Testing Blackbox

The test results in this section are designed for the testing phase with several kinds of processes and stages. This application will be tested by trying all the features to get the results.

Table 1. Testing Blackbox

No.	Menu	Process & Install	Information
1	Splash Screen	Displays SplashScreen	Success
2	Main menu	Main Menu Displays	Success

No.	Menu	Process & Install	Information
3	Option language	Display Option of Language (English, Arab, Indo)	Success
4	Menu of Astronomy (English, Arab, Indo)	Detail Page Display	Success
5	Menu of Botany (English, Arab, Indo)	Detail Page Display	Success
6	Menu of Embryology (English, Arab, Indo)	Detail Page Display	Success
7	Menu of Physiology (English, Arab, Indo)	Detail Page Display	Success
8	Menu Detail of Geology (English, Arab, Indo)	Detail Page Display	Success
9	Menu of Zoology (English, Arab, Indo)	Detail Page Display	Success
10	Menu of Hidrology (English, Arab, Indo)	Detail Page Display	Success
11	Menu of Medicine (English, Arab, Indo)	Detail Page Display	Success
12	Menu of Marine (English, Arab, Indo)	Detail Page Display	Success
13	Menu of General Knowledge (English, Arab, Indo)	Detail Page Display	Success
14	Menu of Biology (English, Arab, Indo)	Detail Page Display	Success
15	Menu of Physics (English, Arab, Indo)	Detail Page Display	Success

After applying it to each student's smartphone, the result was that all the designed applications could be opened smoothly. This indicates that the use of mobile learning-based applications can be applied well (Nuri et al., 2023). The characteristic of the developed Android application that integrates the use of digital tools and resources gives teaching materials advantages that are expected to increase students' digital literacy (Febriyanti & Ain, 2021).

Testing Hardware

In this section, the author tests the user interface on several devices or versions of Android. The following is a summary of the results from testing the Science Interpretation Laboratory application.

Table 2. Testing Hardware

No.	Android Version	Results
1	Android 12	6.38 inci
2	Android 14	6.6 inci
3	Android 11	6.5 inci
4	Android 10	6.5 inci
5	Android 6	5.5 inci

The discussions carried out in redesigning the Science Interpretation Laboratory application included improvements to the display style and the addition of features and language material. Then researchers can increase the level of user satisfaction. These steps are in line with continuous efforts to improve the quality of applications and provide optimal learning experiences (Lagowski, 1995). This finding is consistent with some earlier research showing that the percentage of people eligible for media testing is rising from small-scale to large-scale (Cahyana et al., 2018).

Testing Learning Materials

This testing stage is designed with the main aim of producing a careful evaluation of the material presented in the learning application. This testing process was implemented by involving an expert on Qur'an interpretation material at Universitas Darussalam Gontor, namely Dr. Aqdi Rofiq Asnawi, Lc, M.A He holds the role of Lecturer in the Qur'an and Tafsir Studies Program with a specialization in the field of Tafsir Science.

This test is carried out to assess the quality, accuracy, and usefulness of the material presented in the application as learning material for users. Aqdi Rofiq Asnawi, Lc., M. A. as an expert on scientific interpretation material, provides in-depth views and assessments of the content provided.

The results of the test obtained are presented in detail in the table below. This table reflects expert assessments of various aspects of the material and will be an important guide in improving and perfecting the content of learning applications.

Table 3. Testing Learning Materials

No.	Questionnaire Questions	Score	Max
1	Suitability Language of the Material Presented in the Application	5	5
2	Material Organized	5	5
3	Students are Capable of Providing Scientific Arguments in the Islamic Worldview	5	5
4	Students can Prove Scientific Concepts Contained in the Al-Quran	5	5
5	Communicative Use of 3 Languages	4	5
6	Sentences with an Easy Level of Understanding	4	5
7	Sentences are Easy to Understand	5	5
8	Students are Capable of Understanding the Flow of Material in the Application	5	5
9	Ease of Material to Understand	5	5
10	Expected Function (Supporting Learning)	4	5
Amount		**47**	**50**
Percentage		**94%**	**100%**

After going through a testing process by a Science Interpretation lecturer at Universitas Darussalam Gontor, the material in this research application managed to achieve a score of 94%, which shows a very high level of satisfaction. These results indicate that the material presented in this application fulfills the criteria for being very satisfied, and provides a solid basis to be used as a learning media. By achieving high marks from experts in the field, the suitability of the material to the satisfaction criteria is something worth paying attention to. Therefore, plagiarism checks will then be carried out on each material presented, to ensure the integrity and authenticity of the learning content that will be implemented.

This is in line with the fact that digitally based e-modules exhibit validation results that fall under the category of legitimate and theoretically possible (Sa'diyah, 2021). The existence of e-modules can increase student participation in the learning process (Wahyuni et al., 2022).

Testing by a Learning Media Expert

This media testing is carried out to evaluate the results of various aspects of application design, including images and text. In the context of this testing, the assessment was given by a learning media expert at Universitas Darussalam Gontor and the Dean of the Tarbiyah Faculty, namely Dr. Agus Budiman, M.Pd.

Table 4. Media Expert Validation Test Results

No.	Questionnaire Questions	Score	Max
1	Icons/Buttons that are Easy to use when using Media	4	5
2	Presentation in the Initial Display to Make it Easier to Determine the Next Activity	4	5
3	Clarity of Menus and Materials in the Media	5	5
4	User Suitability of Text colors and Fonts used	4	5
5	The Suitability of the Image Presented in the Media Display	4	5
6	Sentences are Easy to Understand	5	5
7	The Presentation of Material Allows Students to Study Independently	5	5
8	The Interface Design for the Science Interpretation Laboratory Mobile Learning Media is Good	5	5
9	Determination of Color Selection, Type, and Size of Letters on the Media	5	5
10	Ease and Simplicity in Operation	4	5
Amount		**45**	**50**
Percentage		**90%**	**100%**

After going through the testing phase by an expert in learning media, the results showed that this research application succeeded in achieving a score of 90%, reflecting a high level of satisfaction from the assessment. This evaluation covers various aspects of the application design, including images and text, and shows that the application fulfills the satisfaction criteria very well. The results

of this research indicate that the application has succeeded in meeting the expected standards in terms of design and functionality. In addition, Dr. Agus Budiman, M.Pd. as a learning media expert provides constructive direction and evaluation for further application development so that the application can continue to be improved and perfected according to user needs and expectations. This evaluation becomes an important basis for further development to improve the quality and effectiveness of the application.

In line with Wahyuni et al., (2022) Android-based mobile learning that is tailored to their needs can attract students' interest in using it. As stated by Gani et al., (2022) it is more practical and effective to use in the learning process. Innovate by creating learning media that make use of recent technology advancements to assist educators in providing content to support students' learning. When technology is used effectively in the classroom, it will help students access information and engage in learning activities (Cahya et al., 2020).

Testing of Learning Media by Students

Besides that, this learning media was tested by 38 students from the Qur'an and Tafsir study program. Then, questionnaire questions were given related to the Science Interpretation Laboratory learning media.

Table 5. Testing of Learning Media by Students

No.	Element	Value
1	I can Study Online and Independently with Android-Based Mobile Media	90%
2	I can Study According to my Independent Learning Activities and Intensity	88.42%
3	The Science Interpretation Material Presented is Easy to Understand	91%
4	With the Mobile Learning Media of the Science Interpretation Laboratory, I Gained More Knowledge about Science Interpretation Material	94.73%
5	I can Read the Text Easily Because of the Accuracy of the Type and Size of Letters used in the Science Interpretation Laboratory Mobile Learning Media	91%
6	I Like the Appearance of the Science Interpretation Laboratory Mobile Learning Media Because it has a Harmonious Color Composition	95.78%
7	I can Understand Science Interpretation Material with the Help of Good-Quality Pictures	94.21%
8	I can use the Buttons on the Science Interpretation Laboratory Mobile Learning Media Easily	94.21%
9	I Use The Science Interpretation Laboratory Mobile Learning Media to Learn Anytime and Anywhere	95.26%
10	I can use the Science Interpretation Laboratory Mobile Learning Media in Various Languages (Indonesian, English, Arabic)	97.36%
Average		**93.21%**

The results of testing by users or students showed a variety of assessments, but researchers managed to achieve an average score of 93.21%. Testing involved 38 Qur'an and Tafsir Science students from semesters 4, 6, and 8. These results reflect a positive response from students to this application, indicating that the application has succeeded in meeting the criteria for excellent satisfaction.

Students respond very favorably to enjoyable learning, which influences their interest in the material, classroom activities, and enhanced learning results. According to an examination of student response surveys, there was a very favorable reaction in terms of interest, response, interest, contentment, and motivation, indicating that Android-based mobile learning modules are being used in the learning process (Nuri et al., 2023). This occurs as a result of the goods' development to enhance the learning process by making it more engaging, varied, and simpler for students to comprehend ideas (Rismayanti et al., 2022).

The high average score confirms that the majority of students are satisfied and see this application as an effective and useful tool in supporting the learning of Qur'an and Tafsir studies. Evaluations from these students are an important parameter in assessing the success and acceptance of applications, as well as guiding researchers to continue improving the quality and functionality of applications to better fulfill user needs in the future.

Discussion

The redesigned Labtafsin 2.0 application has several developments, including in terms of appearance and content. The structure that has changed is the choice of Arabic, Indonesian, and English, and the material presented is: Astronomy, Botany, Embryology, Physiology, Geology, Animals, Hydrology, Medicine, Marine Affairs, General Knowledge, Biology, Physics. These themes are part of the form of jazz of the Qur'an which is mentioned in several verses and are then interpreted and referred to as tafsir ilmy. This Ilmy interpretation is a form of answer to the doubt that science and religion cannot be united, but with this Ilmy interpretation, it indicates that science and religion or science and the Koran can be united (Habibullah et al., 2024).

The existence of an interpretation laboratory application is an effort to support the development of technology presented in the contents of the Koran so that science and religion can be united and go hand in hand (Kamil et al., 2021). Then the Labtafsin application is presented with an attractive appearance, Through the Reading View, this application provides an interactive learning experience with material explanations, arguments, and image visualization to facilitate users' understanding of science interpretation material. Thus, it is hoped that the Science Interpretation Laboratory Application can become an effective learning tool and support students' understanding of science interpretation concepts. In addition to the scientific interpretation explanations provided, the Labtafsin 2.0 application is also supported by references. In line with Hendri et al., (2021) valid digital modules are by the basic content and main material with development with clear learning objectives that can make it easier for students to understand. This is in line with the assertion that e-modules are beneficial for improving pupil participation in the learning process (Feriyanti et al., 2019).

After the design process for the science interpretation laboratory 2.0, researchers tested its use both in terms of the effectiveness of the application performance and the feasibility of its use by experts in Al-Qur'an interpretation material and learning media experts, as well as responses to its use by students of the Al-Qur'an science study program and interpretation. From black box testing, namely the application's ability to run all menus, it got successful results. Meanwhile, the hardware test results in the form of application operation in several versions of Android obtained successful results with at least the Android 10 version which allowed the application to run smoothly. This finding is consistent with some earlier research showing that the percentage of people eligible for media testing is increasing from small-scale to large-scale (Cahyana et al., 2018). With operational capabilities on many Android versions, it will make it easier for smartphone users to run this application

Then application testing was carried out again to determine the feasibility of using it for Al-Qur'an interpretation material and also learning media. The material experts gave an average score of 94%, which indicates that the application can be used as a learning resource and makes it very easy to learn scientific interpretations of the Koran. According to this description, the creation of teaching materials for Android-based mobile learning modules is deemed valid since they satisfy the content and construct feasibility requirements, making the modules suitable for use as science teaching materials (Nuri et al., 2023). Meanwhile, learning media experts obtained an average result of 90%, which indicates that this application is effective for use as a learning media. When technology is used effectively in the classroom, it will help students access information and engage in learning activities (Cahya et al., 2020).

After being tested for its suitability by experts in the field of learning materials and media, this application was again tested in its use by students, from 38 respondents it produced an average score of 93.21%, which indicates that students found it easy and very helpful by this application. By using mobile learning, students can learn anytime and anywhere, so they can overcome limitations in location and time to be able to learn independently from the resources provided (Susilo & Prasetyo, 2020).

Next, it is important to plan sustainable development steps. The evaluation and improvements made so far should be followed by regular updates that maintain the reliability and relevance of the application over time (Muriyatmoko et al., 2019). This ongoing development process will help keep

the application compatible with future user needs and expectations. Thus, this application can be an effective and reliable learning source within the Qur'an and Tafsir Study Program environment.

CONCLUSION

Conclusions were found based on the results of research and trials of the Science Interpretation Laboratory application, while suggestions were made for improvement and further development, with the following explanation: The research succeeded in redesigning the Science Interpretation Laboratory application in the second development stage, with the addition of 3 language features (Arabic, English, and Indonesian). The functionality test (black box) results show that the application runs smoothly and can be used optimally on devices with at least Android version 10. Assessments from material experts give an average of 94%, indicating that this application is suitable for publication as an e-book learning resource. Assessment from media experts provides an average score of 90%, with several suggestions for improvement. Although there are several suggestions, in general, the application is rated very satisfied. The assessment results from Qur'an and Tafsir Studies students showed a score of 93%, which included responses from 38 students. From the results of this research, the Science Interpretation Laboratory application is suitable for public use, although there are several more things that need to be added. Based on the conclusions of this research, the author recommends several suggestions for further development such as the addition of Video and Quiz features according to the material being studied. And adding the Al-Qur'an with translation, and some interpretations can be studied.

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Case study: Impact analysis of educational Chatbot use in supporting students in the online learning process

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ABSTRACT

This research aims to analyze the impact of using educational chatbots in supporting students in online learning processes. The research methodology adopts a qualitative approach with a case study design to examine the effects of chatbot usage on students in online learning. Data collection techniques involve conducting in-depth interviews with students, teachers, and school administrators, engaging in participatory observation during online learning sessions, and analyzing official documents and chatbot interaction logs. The research findings indicate that the use of chatbots significantly enhances student engagement, facilitates quick access to information, and provides personalized support in understanding the material. Furthermore, chatbots successfully create an interactive and responsive learning environment, boosting students' learning motivation and problem-solving abilities. The primary conclusion drawn from this research is that educational chatbots have a positive impact on improving the effectiveness of online learning by strengthening the interaction between students and the learning platform. The implementation of chatbots can be an effective solution to enhance the efficiency and quality of student's learning experiences in virtual environments. These findings offer valuable insights for further development in integrating chatbot technology into the context of online education, with the potential to improve accessibility, effectiveness, and holistic student experiences in distance learning.

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INTRODUCTION

Education plays a very important role in the development of individuals and society as a whole (Kusumawati et al., 2023). With the rapid advancement of information technology, a new paradigm in the learning process has emerged, one of which is through the implementation of educational chatbots. Educational chatbots are computer programs designed to interact with users through text or voice conversations and have become an integral part of digital transformation in education. Along with the rise of online learning, there is an urgent need to address the challenges faced by students and educators in virtual learning environments (Bakare & Jatto, 2023). Online learning offers significant flexibility in terms of time and location, allowing students to study according to their

schedules. However, a major challenge with online learning is the lack of direct interaction between teachers and students, which often hinders personalized support and instant clarification of material. According to Gimhani (2023), Online education still struggles to optimize interaction and support for students, which impacts learning effectiveness.

Educational chatbots are emerging as a promising innovative solution to enhance the online learning experience. Chatbots can act as virtual agents that provide quick responses, relevant information, and personalized support to students. As such, chatbots can help bridge the gap between students' need for immediate assistance and educators' limited time and capacity to provide individualized support (Bakare & Jatto, 2023). Educational chatbots have significant potential to enhance the online learning experience, but the main challenges faced are effectiveness, student acceptance, and integration of this technology into existing learning systems. These challenges include ensuring the effectiveness of chatbots in improving learning outcomes, the level of acceptance and adaptation by students, and the integration of this technology into existing learning systems (Mahendra et al., 2024). To address these challenges, it is important to explore the extent to which chatbots can positively impact online learning and how students can accept and adopt this technology in their daily learning activities. One approach is to effectively integrate chatbots into existing online learning platforms, encouraging innovation without requiring significant changes to existing learning infrastructure. In this way, educational institutions can take advantage of new technologies while maintaining established and effective learning systems (Mahendra et al., 2024).

Recent years have seen a significant increase in the adoption of technology in education, particularly in online learning. Educational chatbots are emerging as innovative tools designed to provide instant learning support to students (Aksenta et al., 2023). This technology offers the potential to address some of the key challenges faced in online learning, such as the lack of direct interaction and personalized support from educators. However, although educational chatbots have been widely discussed in the literature, many educational institutions still experience difficulties in effectively implementing and optimizing this technology (Mahendra et al., 2024). Many previous studies have focused more on the technical development of chatbots rather than their impact on learning and user acceptance in real educational environments (Pustikayasa et al., 2023).

The problems faced in implementing an educational chatbot at Junior High School 1 Tigo Nagari are related to the effectiveness and acceptance of this technology in supporting the online learning process. In an educational environment that is increasingly adopting online learning, students often face difficulties in getting instant help and clarification of material. The lack of direct interaction between teachers and students often results in gaps in material understanding and personalized support for students. Educational chatbots present a potential solution to this challenge by providing quick responses and personalized support that can be tailored to students' individual needs. However, the success of this chatbot implementation depends on the extent to which students and teachers can accept and utilize this technology effectively. The impact analysis of using the chatbot at Junior High School 1 Tigo Nagari also faces challenges in measuring how much the chatbot contributes to improving learning quality and student engagement. In addition, there are concerns regarding the integration of chatbots into the existing learning system, especially in ensuring that this technology does not replace the important role of teachers but instead strengthens the interaction and support provided to students.

The integration of chatbots in the education sector has been the subject of systematic review and analysis by various researchers, which provides a comprehensive framework as well as valuable insights into the development and implementation of this technology in the educational context. The systematic literature review by Pérez (2020) provides a solid foundation for research and development, highlighting the potential of chatbots to improve educational outcomes through reliable and informative findings. This systematic approach is essential to guide future efforts in utilizing chatbots for educational purposes. In the same way, Wollny (2021) review investigated the current applications of chatbots in education, emphasizing their pedagogical role, their use in tutoring, and their potential to personalize the learning experience. This comprehensive review highlights the various ways in which chatbots can contribute to educational practice, particularly in enhancing personalized learning experiences.

Kuhail (2023) further extends this understanding by reviewing the educational chatbot landscape through a multidimensional lens, focusing on aspects such as educational field, platform, design principles, chatbot role, interaction style, evidence, and limitations. This analysis offers a holistic view, providing valuable insights for educators, developers, and researchers looking to integrate chatbots into educational settings. Additionally, Chocarro (2023) explored teachers' attitudes toward educational chatbots using a technology acceptance model. The study considered factors such as social language, bot proactivity, and user characteristics, providing important insights into the perception and acceptance of chatbots by educators. This research highlights the human factors that influence the successful integration of chatbots in educational environments. This systematic review collectively emphasizes the transformational potential of chatbots in education and highlights the need for careful consideration of various factors to successfully implement them in educational settings.

This research builds on previous studies that have examined the use of technology in education. However, the novelty of this research lies in its focus on analyzing the impact of using educational chatbots which has not been fully explored. Along with recent developments in technology and online learning, this research seeks to answer open questions regarding the effectiveness of chatbots as learning support tools. This research highlights the specific impact of using educational chatbots in online learning at Junior High School 1 Tigo Nagari, which has not been explored in previous literature. By focusing on Junior High Schools in Indonesia, this research presents a new perspective on how this technology can be adapted to diverse educational environments that differ from education in developed countries.

Therefore, this study aims to analyze the impact of using educational chatbots in supporting students in the online learning process. This research aims to comprehensively analyze the impact of using educational chatbots in supporting students in the online learning process. This objective also involves identifying key factors that influence the acceptance and effectiveness of chatbots in online learning environments. The importance of this research is not only reflected in technological advances but also in the urgent need to improve the quality of online learning. Educational chatbots promise the possibility to change the learning paradigm, making it more interactive, responsive, and tailored to individual needs. With a chatbot in place, it is expected that students can obtain help and information more efficiently, thus enhancing their learning experience. The rationality of this research lies in the attempt to address the existing challenges in online learning and provide solutions that can improve the quality and effectiveness of the learning process.

This research has an important role to play in improving the quality and effectiveness of online learning. By analyzing the impact of using educational chatbots, this research provides in-depth insight into how such technology can increase student engagement, provide personalized support, and stimulate learning motivation. This is all the more important given the rapid development of technology and the shift towards widespread online-based learning. Firstly, this research provides empirical insights into how chatbots can improve the effectiveness of online learning, particularly at Junior High School 1 Tigo Nagari. Second, the results can guide educational institutions in implementing and optimizing the use of educational chatbots, with evidence-based recommendations. Thirdly, this study enriches the existing literature by highlighting the importance of local context in the adoption of educational technology and emphasizing the need for proper integration so that the technology serves as a supporting tool, not a substitute for the role of teachers. Finally, it paves the way for further research into the use of technology in education in Indonesia and other developing countries with unique challenges and needs. By detailing these objectives, this research is expected to provide a meaningful understanding of the application and impact of chatbots in online learning.

METHOD

This research uses a qualitative method with a case study approach to analyze the impact of using educational chatbots in supporting students in the online learning process at Junior High School 1 Tigo Nagari. The case study approach was chosen because it allows researchers to explore the

phenomenon in depth in a real and specific context. Data were collected through direct observation, in-depth interviews with 3 students, 3 teachers, and 1 school administrator, and document analysis related to the use of chatbots in learning. The interviews were semi-structured to gain richer and deeper insights into the participants' experiences and perceptions of using chatbots. Direct observation was conducted during several online learning sessions to see the interaction between students and chatbots in the context of the virtual classroom. The data obtained were thematically analyzed to identify patterns, themes, and relationships relevant to the impact of chatbot use on student learning. Triangulation procedures were applied to increase data validity and reliability by comparing findings from multiple data sources. The results of the analysis are expected to provide a more comprehensive understanding of how chatbots can support the student learning process and the challenges faced in the implementation of this technology in educational settings (Devi, 2023).

RESULTS AND DISCUSSION

Results

Student and Chatbot Contextual Interaction

Table 1. Question type and Frequency

No.	Question type	Frequency
1	Subject Matter	120
2	Assignment Help	75
3	General School Information	30

Table 1 provides a comprehensive overview of the types of questions most frequently asked by students to the chatbot. Based on an interview with a student with the initials NH, he revealed that he interacted more frequently with the chatbot to ask about the subject matter, with a total of 120 related questions. This shows that the chatbot has been successful in providing effective support in understanding difficult subject concepts. The use of natural language processing technology by the chatbot allows for a better understanding of student questions, resulting in more relevant and informative answers. This is supported by direct observation, where it was seen that students often ask questions related to subjects such as math and science, which many students find difficult.

It is important to note that a chatbot's quick and relevant response to student queries has a positive impact on the online learning experience. The ability of chatbots to provide information instantly helps students overcome barriers to understanding efficiently. In addition, the frequency with which students ask questions about subject matter suggests that chatbots can be a highly effective tool in supporting their learning process (Tanduklangi & Amri, 2019). In addition to subject matter, assignment assistance also attracted attention in the data analysis. The frequency of assignment-related questions suggests that chatbots can serve as a valuable tool for students in completing their assignments. The chatbot can provide guidance, explain difficult concepts, or give advice needed to complete the task well (Ruskandi et al., 2021).

During the interview, students with the initials NH revealed that the chatbot helped them understand the material taught in class better. They feel more comfortable asking questions to the chatbot because they do not feel worried if their questions are considered trivial. Students B and AK also stated that the chatbot helped them prepare for exams by providing material summaries and practice questions. This more interactive learning experience helps to increase students' motivation and engagement in online learning. In addition to subject matter, chatbots are also frequently used to get assignment help. With a frequency of 75 questions related to assignment help, B often asked for guidance or clarification on assignments given by teachers. The chatbot provided useful suggestions and strategies for completing the assignment, as well as explaining concepts that were difficult to understand. This suggests that the chatbot can serve as a valuable tool in supporting Bs to complete their tasks independently (Manuaba et al., 2024). AKs stated that the chatbot's ability to provide instant answers helped them save time and complete tasks more efficiently.

Teachers at Junior High School 1 Tigo Nagari have a positive view towards the use of chatbots as a learning support tool. TH noted that chatbots help ease the workload by answering basic

questions frequently asked by students. As such, teachers can focus more on teaching more complex material and give more attention to students who need further guidance. GE reports that students who actively use chatbots tend to be better prepared and participate more in class discussions. This suggests that chatbots encourage students to be more independent in seeking information and solving problems. However, some teachers also highlighted the challenges associated with using chatbots. S expressed concern that students may rely too much on the chatbot for quick answers, which may hinder the development of their critical thinking and problem-solving skills. S emphasized the importance of integrating the use of chatbots with teaching approaches that encourage students to think critically and independently. They also emphasized the need for training for students to make optimal use of chatbot features and ask effective questions.

School administrators stated that the integration of chatbots into the school's online learning system has improved the efficiency of communication between students and the school. The chatbot has helped deliver general information, such as class schedules and school announcements, more effectively. With 30 interactions related to general school information, the chatbot serves as an efficient communication tool between students and the school, reducing the need for repeated administrative queries to school staff. IY also recognized the challenges in managing this new technology. IY noted that there is a need to ensure that the chatbot is constantly updated with the latest and relevant information. This requires close collaboration between the technology developers and school staff to ensure that the chatbot can provide accurate and up-to-date information. In addition, there is a need to continuously monitor the use of the chatbot to ensure that this technology is used ethically and does not interfere with students' learning.

Optimizing the use of chatbots, and understanding daily interaction patterns is crucial. Analysis of the frequency of interactions on certain days can help in determining the optimal schedule of the chatbot. For example, on days with high interaction rates, increased chatbot availability can be considered to ensure that all students get the support they need (Sholeh & Fudholi, 2020). These steps can increase the effectiveness of the chatbot in supporting the overall student learning process. In addition, understanding student preferences and needs through interaction patterns can aid the development of additional content or improved chatbot functionality to meet evolving demands in a dynamic online learning environment. For example, chatbots can be developed to provide more in-depth explanations of certain topics or provide additional relevant learning resources (Sholeh & Fudholi, 2020).

This research shows that educational chatbots have great potential to enhance the online learning process by creating a more interactive and responsive learning environment. However, to maximize its benefits, a comprehensive approach involving all stakeholders, including students, teachers, school administrators, and technology developers, is required. In this way, chatbots can be an effective tool to enrich students' learning experience and improve educational outcomes at Junior High School 1 Tigo Nagari.

Student Perception of Chatbot

Students' perception of chatbots in education is an important aspect to understand to optimize their use in the learning process. In recent years, chatbots have become one of the technological innovations that are increasingly being implemented in various educational institutions. The use of chatbots in education has become an increasingly common phenomenon along with the advancement of digital technology. At Junior High School 1 Tigo Nagari, the implementation of chatbots in online learning has triggered various reactions from students, which provides valuable insights into the effectiveness and acceptability of this technology. Students' perceptions of chatbots vary widely, covering aspects of practicality, engagement, and effectiveness in improving material understanding (Wahyuni, 2022).

The importance of understanding students' perceptions of chatbots lies in building a learning system that suits their needs and preferences. NHs perceive chatbots as an innovative solution that can improve learning efficiency, while others may feel skeptical or even anxious about their use (Fikri et al., 2023). Therefore, research on student perceptions of chatbots can provide valuable insights to improve the design and implementation of chatbots in educational settings.

Direct observation and in-depth interviews with B show that most students consider chatbots as a practical and efficient tool in supporting their learning. AK appreciated the ease of access provided by the chatbot, especially in terms of obtaining information related to course materials and school assignments. Many students feel that chatbots can provide quick and relevant answers, allowing them to solve questions and problems they face in a shorter time compared to waiting for responses from teachers or classmates (Azhar & Nasution, 2023). B mentioned that chatbots provide a more engaging and interactive learning experience. Features such as practice questions, interactive quizzes, and structured explanations help to increase student engagement in learning. Students who prefer to learn independently find that chatbots are ideal study companions, who can be relied upon to provide additional explanations when they encounter difficulties. The chatbot's natural language processing allows for more natural and personalized interactions, making students feel more comfortable and engaged in the learning process (Mawardi et al., 2024).

However, some students expressed skepticism towards the use of chatbots. AK felt that chatbots cannot replace direct interaction with teachers, especially when it comes to explaining complex concepts. Previous unsatisfactory experiences with similar technologies may influence their perception of chatbots. Students who experience difficulties in navigating the user interface or getting satisfactory answers from the chatbot may feel less comfortable and reluctant to interact further with this technology.

Document analysis and interviews with teachers revealed that the use of chatbots generally improved students' understanding of the subject matter. A graph of the interaction results showed a positive correlation between the frequency of chatbot use and the improvement of students' scores in exams and assignments. TH noted that students who actively used the chatbot tended to show improvement in basic concept understanding and analytical ability. The chatbot provided significant additional support, especially for students who needed more detailed explanations or assistance in completing homework assignments. GE also observed that students who frequently interacted with the chatbot showed improvement in learning independence. They are more willing to ask questions and explore the material in depth, which is an indication that the chatbot has encouraged them to be more actively involved in the learning process. However, the effectiveness of the chatbot in improving material understanding is inseparable from the teacher's role in providing guidance and support. Teachers who provide clear orientation and feedback on the use of chatbots help students to better utilize the features available and understand how this technology can help them learn (Manongga et al., 2022).

The views of teachers and school administrators play an important role in shaping students' perceptions of the use of chatbots. Teachers who are actively involved in the implementation of this technology, provide support, and motivate students to use it, help to increase students' acceptance of chatbots. In the interviews, S stated that they have seen a positive impact from using chatbots in their classes, and they plan to continue utilizing them in learning. GE also highlighted the importance of integrating chatbots with existing teaching methods, so that students can see how this technology can complement traditional learning. School administrators felt that the integration of chatbots has provided significant benefits in terms of efficiency and communication. It has made it easier to deliver important information to students, reduced administrative burdens, and improved the accessibility of learning resources. However, IY also recognizes the challenge of ensuring that this technology is continuously updated and relevant to students' needs. Collaboration between technology developers, educators, and students is crucial to ensure that chatbots can meet learning expectations and needs (Hadian et al., 2023).

Some of the factors that influence students' perceptions of chatbots include clarity of purpose of use, a friendly user interface, and the chatbot's ability to provide adequate responses. Students who have a clear understanding of the functions and benefits of chatbots tend to have a more positive perception of their use (Raharjo, 2023). Therefore, it is important to give students a good orientation on how to utilize this technology effectively. A friendly and intuitive user interface is also a key factor in shaping student perceptions. Students who feel comfortable and easy to interact with chatbots tend to use them more often as learning aids. Conversely, students who experience difficulties in accessing the chatbot's features or get unsatisfactory answers may feel less interested in using it. The chatbot's ability to provide adequate and relevant responses also greatly influences

students' perceptions. Students appreciate chatbots that can provide precise answers and clear explanations. Therefore, chatbot development should focus on improving the quality of responses and the ability to better understand student questions.

Student perceptions of chatbots in education have significant implications for their acceptance and successful implementation. Therefore, chatbot development in an educational context should consider the diversity of student perceptions to ensure its sustainability and successful use in improving the quality of learning. This research recommends that schools continue to evaluate and adjust the use of chatbots, based on feedback from students and teachers. Continuous training and orientation for students and teachers on the use of chatbots can help improve understanding and skills in utilizing this technology. In addition, it is important to further develop the features of the chatbot to make it more responsive and relevant to the evolving needs of education (Sabri, 2020).

This research shows that chatbots have great potential to enhance students' learning experience by providing flexible and responsive additional support. However, to maximize its benefits, a comprehensive approach involving all stakeholders, including students, teachers, school administrators, and technology developers, is required. In this way, chatbots can be an effective tool to enrich students' learning experience and improve educational outcomes at Junior High School 1 Tigo Nagari.

Sustainability of Chatbot Usage

The utilization of chatbots as a learning support tool has become a significant innovation in various educational institutions. At Junior High School 1 Tigo Nagari, this study explores the long-term sustainability of chatbot use by considering its effectiveness, user acceptance, challenges faced, and strategies to improve the sustainability of its implementation. Various methods, including direct observation, in-depth interviews with students, teachers, and school administrators, as well as analysis of related documents, were used to gain comprehensive insights into the implementation of chatbots in the learning process.

One of the main factors influencing the continued use of chatbots is their effectiveness in helping students achieve learning objectives. Based on direct observations and interviews with students, it is apparent that chatbots play an important role in improving students' understanding of the subject matter. NHs reported that their interaction with the chatbot had a positive impact on concept understanding and analytical skills. The chatbot successfully provided relevant answers and clear explanations, which helped students overcome the difficulties they faced in the learning process (Sugiono, 2021). In addition, chatbots provide significant additional support, especially for students who require further assistance in completing assignments or understanding difficult material. The effectiveness of chatbots in providing timely and informative responses also encourages students to interact with them more frequently, which in turn increases their understanding and engagement in the learning process. Thus, the effectiveness of chatbots becomes one of the key factors in ensuring their continued use in educational settings (Lubis & Sumartono, 2023).

The continued use of the chatbot is also closely related to user acceptance, particularly in terms of student perceptions and preferences. The results of the in-depth interviews showed that while many students responded positively to the chatbot, their preferences and needs may change over time. AKs state that they appreciate the ease of access and flexibility provided by chatbots, while others feel that chatbots cannot fully replace the role of teachers in learning (Cannavaro, 2023). To understand these changing perceptions, it is necessary to conduct ongoing research that monitors how students respond to the use of chatbots over time. Developing and adjusting the chatbot design to remain relevant to the evolving needs of users is important to maintain its acceptance and sustainability. In addition, it is important to involve students in the chatbot development process, by integrating their feedback to improve the user experience.

The use of chatbots in education cannot be separated from technical and non-technical challenges. From a technical perspective, the security, data integrity, and performance aspects of the chatbot must be maintained so as not to raise doubts or distrust from users. Document analysis shows that schools have taken steps to ensure student data security and improve chatbot performance, but these challenges require constant attention to ensure the sustainability of chatbot use (Subiyantoro,

2023). On the other hand, non-technical challenges such as a lack of understanding or support from stakeholders, such as teachers and parents, can be a significant barrier. Interviews with S and IY revealed that while most support the use of chatbots, there is still a need to improve their understanding of how to effectively utilize this technology. Managing this challenge is essential to ensure the sustainability of chatbot implementation.

A strategy of continuous development and improvement is key to maintaining the sustainability of the chatbot. The integration of feedback from users, both students and teachers, can be the foundation for the development of new features or improvements to the chatbot. Interviews with B students showed that they appreciated interactive features such as practice questions and quizzes, and wanted more content that could be customized to their individual needs (Nasution et al., 2023). It is also necessary to continuously improve the artificial intelligence of the chatbot so that it can adapt to the needs and development of the education curriculum. In an interview with school administrator IY, it was revealed that further development of the chatbot's ability to better understand and respond to student questions is a priority. This could include improved natural language processing and integration with other learning technologies to create a holistic learning ecosystem. The role of teachers in supporting the continued use of chatbots should not be overlooked. Teacher support can include robust training to optimize the use of chatbots in the learning process, as well as guiding students in utilizing chatbots effectively. Collaboration between teachers and technology is key to creating a positive learning experience and ensuring that chatbots can serve as an effective support tool in learning (Pustikayasa et al., 2023).

As a potential solution to improve sustainability, the integration of chatbots with online learning platforms or learning management systems can be an effective strategy (Rochmawati et al., 2023). As such, the chatbot can be more easily accessed by students and integrated into wider learning. Interviews with school administrator IY indicated that this integration could improve the accessibility and use of the chatbot by students, as well as enable better monitoring of student interactions and learning outcomes. Improving the interoperability of chatbots with other technologies, such as learning management systems and educational apps, can be an important step toward addressing sustainability challenges. With good integration, chatbots can serve as an integral part of the digital learning ecosystem, providing consistent and relevant support to students.

The sustainable use of chatbots in education requires a holistic approach that includes continuous evaluation, response to changing user perceptions, handling technical and non-technical challenges, and continuous development. The results of this study show that by paying attention to these aspects, chatbots can remain an effective and value-added tool in supporting the learning process. To ensure the sustainability of chatbot use, a collaboration between all stakeholders, including students, teachers, school administrators, and technology developers, is required. Thus, chatbots can continue to make a positive contribution to the development of education, create innovative learning environments, and improve the overall quality of the student learning experience. With strong support and commitment from all relevant parties, the sustainable use of chatbots in education can be achieved, making them an integral part of the modern learning ecosystem.

Impact on the Effectiveness of Online Learning

Online education or online learning has become the main choice in facing various challenges, including the global pandemic. Despite its advantages, online education also has several impacts on learning effectiveness. It is important to understand these impacts to optimize the online learning process and overcome potential obstacles that may arise. One of the main impacts of online learning is the flexibility of time and place (Khusniyah & Hakim, 2019). Students have the freedom to set their learning schedule and access learning materials from anywhere. However, this freedom can also lead to challenges, such as lack of study discipline and procrastination. The table below details some of the positive and negative impacts of online learning flexibility.

Table 2. Impact of Positive Flexibility and Negative Flexibility

No.	Impacts	Positive flexibility	Negative flexibility
1	Positive	Facilitate Individual Learning Activities Accommodates Various Learning Styles.	Procrastination due to Time Constraints. Lack of a Planned Learning Structure.

No.	Impacts	Positive flexibility	Negative flexibility
2	Negative	Increase Student Independence. Leads to Learning Indiscipline. Requires High Self-Motivation.	Difficulty Managing Time Efficiently. Lack of Social Interaction and Collaboration.

Table 2 illustrates that flexibility in online learning has brought significant impacts, both in positive and negative aspects. On the positive side, time and place flexibility facilitate individual learning activities, allowing students to design learning patterns that suit their individual needs and preferences. One of the main advantages of online education is the flexibility of time and place it offers to students. Based on observations and interviews with 3 students at Junior High School 1 Tigo Nagari, it was found that many students appreciate the freedom given to set their study schedules and access learning materials from anywhere. This flexibility facilitates individual learning activities and accommodates various learning styles, thus enhancing students' independence. Students who have a busy schedule of activities find it helpful to be able to organize their study time according to their needs, which also allows them to better adjust to the curriculum.

However, this flexibility also poses several challenges that need to be addressed. NHs reported experiencing procrastination and difficulty managing time efficiently. This is largely due to the lack of a planned study structure and the need for high self-motivation. Observations show that students who are not used to independent learning often have difficulty in establishing consistent study discipline. Lack of social interaction and collaboration is also one of the negative aspects of the flexibility of online learning. Despite the various online communication platforms available, students feel that social connection and collaboration in group activities are not as effective as face-to-face learning (Wijaya, 2023).

Online learning also has a significant impact on evaluation and assessment methods. Teachers must adapt to evaluation methods that are suitable for online formats, such as online exams and online assignments. The utilization of technology in evaluation provides advantages in the efficiency and accuracy of the assessment process. Based on interviews with teachers with the initials S, many appreciate the ease of providing quick feedback, which allows students to more quickly understand their strengths and weaknesses. In addition, the flexibility in assessment types allows teachers to adapt assessment methods according to the needs and learning objectives (Pratama et al., 2021). However, challenges remain in measuring non-cognitive skills or "soft skills" such as creativity, cooperation, and communication. While technology can be used for academic evaluation, many teachers report difficulties in accurately assessing the attitudinal and moral aspects of students through online evaluation methods. The risk of academic cheating also increases with the use of technology in evaluation. Students can utilize technology to cheat, which threatens the integrity of the evaluation results. In some interviews, THs expressed concerns about the limitations of providing personalized and in-depth feedback to each student. The following Table 3 provides a more detailed overview of the impact of evaluation in online learning.

Table 3. Impact of Positive Evaluation and Negative Evaluation

No.	Impact	Positive evaluation	Negative Evaluation
1	Positive	Utilization of Technology for Evaluation. Providing Immediate Feedback. Flexibility in Assessment Types.	Risk of Academic Fraud Increases. Difficulty Measuring Skill Aspects.
2	Negative	Limitations in Measuring Skills. Lack of Direct Interaction with the Teacher.	Possibility of Technical Glitches. Difficulty Assessing Attitudinal and Moral Aspects.

Online learning is not free from technical and non-technical challenges that affect its effectiveness. From a technical perspective, the stability of the internet network and access to technological devices are factors that determine the quality of students' learning experience. B reported experiencing technical disruptions such as unstable internet connection or inadequate devices to support online learning. This can disrupt the learning process and reduce students' motivation to actively engage in learning (Amaniyah et al., 2021). On the other hand, non-technical

challenges such as a lack of understanding or support from stakeholders, such as teachers and parents, can be a significant barrier. Observations and interviews with IY school administrators revealed that while most are supportive of the use of online learning, there is still a need to improve their understanding of how to effectively utilize this technology (Daheri et al., 2020).

Overcoming the challenges of online learning and maximizing its benefits requires a comprehensive strategy from all relevant parties. Students need to develop good time management skills and be directed to use supportive online learning tools. In the interview, teacher GE suggested the use of time and task management apps as a way to help students stay organized. Educators can initiate initiatives that encourage collaboration between students, even online, to enrich students' social experiences. By utilizing technology such as online discussion forums and collaborative projects, students can build closer relationships with their peers (Mulyanah & Andriani, 2021). In addition, it is important to continue developing evaluation methods that are more holistic and inclusive. The utilization of technology needs to be balanced with measures to reduce the risk of cheating and ensure the integrity of evaluation results. Teachers need to be trained in online evaluation techniques that can better measure non-cognitive skills. Thus, evaluation in online learning can be a more effective tool to measure students' academic achievement and holistic development (Cahyani et al., 2021).

Online learning has a complex impact on the educational process, with benefits and challenges that must be carefully managed. This research shows that while flexibility and technology offer many benefits, there is a need for a more structured approach and additional support for students and teachers to ensure online learning can be implemented successfully. With strong cooperation between all stakeholders, online learning can continue to grow and make a positive contribution to education in the future.

Discussion

The use of chatbots in online learning at Junior High School 1 Tigo Nagari has shown a significant impact on improving students' learning experience. The chatbot has played an important role in facilitating students' understanding of complex subject matter by providing quick and relevant answers through natural language processing (NLP) technology. This was revealed in a study that showed that students asked questions related to subject matter to chatbots more frequently, with the frequency reaching 120 questions. The use of chatbots not only helps students understand the subject matter but also provides a sense of comfort as students can ask questions without worrying about being judged negatively by teachers or classmates, ultimately increasing their motivation and engagement in online learning.

The chatbot also served as an aid in completing school assignments, with 75 assignment help-related questions submitted by students. Students used the chatbot for guidance and clarification in completing their assignments, suggesting that it can be an effective learning partner in supporting students' independence and preparing them for exams by providing material summaries and practice questions. From a teacher's perspective, chatbots help reduce workload by handling basic questions that frequently arise from students, allowing teachers to focus more on teaching more complex material. However, there is a concern that over-reliance on chatbots may hinder the development of students' critical thinking skills. Therefore, it is important to integrate the use of chatbots with teaching approaches that encourage students to think critically and independently.

The use of chatbots has improved the efficiency of communication between students and schools by facilitating the dissemination of important information such as class schedules and school announcements. This reduces the administrative burden on school staff with 30 interactions related to general school information served by the chatbot. However, the challenge of ensuring timely and accurate information updates demands close cooperation between technology developers and school staff. To optimize the use of the chatbot, analysis of daily interaction patterns can help determine the optimal schedule for increased chatbot availability, thus ensuring that all students get the support they need. Understanding student preferences and needs can also drive the development of additional features or improved chatbot functionality to meet the demands of a dynamic online learning environment (Aksenta et al., 2023).

Students' perceptions of chatbots in online learning vary. Most students appreciate the practicality and efficiency offered by chatbots, especially in providing quick and relevant answers to their questions. Features such as practice questions and interactive quizzes increase student engagement, while natural language processing allows for more personalized interactions. However, some students feel that chatbots cannot fully replace direct interaction with teachers, especially in explaining complex concepts. Therefore, it is important to provide orientation and training to students on how to optimally utilize the chatbot, as well as ensure a friendly and intuitive user interface. The views of teachers and school administrators also influence students' perceptions regarding the use of chatbots. Teachers who are actively involved in the implementation of this technology and provide support can increase students' acceptance of the chatbot. Therefore, this study recommends continuous evaluation and adjustment to the use of the chatbot based on feedback from students and teachers. Ongoing training for all stakeholders is also important to ensure effective and optimal utilization of this technology. Involving all parties in the development and implementation of a chatbot is expected to create a more responsive and interactive learning environment and improve the quality of education at Junior High School 1 Tigo Nagari.

The continued use of chatbots as learning support tools has become a significant topic in various educational institutions. This research highlights the importance of effectiveness, and user acceptance, as well as the challenges faced in chatbot implementation. One of the key findings is that chatbots play an important role in improving students' understanding of subject matter, with students reporting that interaction with chatbots positively impacts their concept understanding and analytical skills. This success was largely due to the chatbot's ability to provide relevant answers and clear explanations, thus helping students overcome learning difficulties. In addition, the chatbot's effectiveness in providing timely responses encouraged increased student interaction, which in turn improved their engagement and comprehension (Gusty et al., 2020).

User acceptance, particularly of students, is also an important factor in the continued use of the chatbot. While many students responded positively to the ease of access and flexibility that the chatbot offers, there is a need to continuously monitor and adjust the chatbot design to suit changing needs and preferences over time. Technical and non-technical challenges, such as data security and support from stakeholders, require special attention to ensure the sustainability of the implementation. Continuous development and improvement strategies, including integration of user feedback and improvement of the chatbot's artificial intelligence, were identified as important steps to maintain the relevance and effectiveness of the chatbot in supporting learning. Teacher support in the use of chatbots is also essential, including adequate training and usage guidance for students. Integration of chatbots with online learning platforms can improve their accessibility and interoperability, making them an integral part of a holistic digital learning ecosystem (Saputra, 2023).

The flexibility of time and place in online learning is one of the main impacts that affect the effectiveness of learning. This flexibility allows students to set their study schedule and access learning materials from anywhere, which can enhance independence and accommodate various learning styles. However, this flexibility can also pose challenges such as procrastination and lack of study discipline, especially for students who are not used to independent learning. The lack of social interaction and collaboration in online learning is also a concern, despite the online communication platforms available (Ulpah et al., 2024). In addition, evaluation methods in online learning require adaptation to address the challenges of measuring non-cognitive skills and the risk of academic cheating. Internet network stability and access to technological devices are also determining factors in the online learning experience, where technical disruptions can hinder the learning process and demotivate students. To optimize online learning, a comprehensive strategy is needed that includes developing students' time management skills, online collaboration initiatives, and more holistic and inclusive evaluation methods. With cooperation between all stakeholders, online learning can continue to grow and make a positive contribution to education in the future. Effective technology integration, attention to student needs, and support from all parties involved will ensure that online learning can fulfill its full potential in improving the quality of education at Junior High School 1 Tigo Nagari.

CONCLUSION

The use of chatbots in education has a significant impact on supporting students in the online learning process. Efficiency, personalization, and quick access to information are some of the advantages that can be obtained through the implementation of chatbots. However, challenges such as loss of social interaction and limitations in providing in-depth understanding need to be overcome by designing learning strategies that are balanced between technology and human interaction. Thus, chatbots can be an effective tool in improving the quality of online learning. In the face of the transformation of education towards online learning, the use of chatbots as a learning support tool has become a topic that has received attention. An analysis of the impact of using chatbots in supporting students in the online learning process reveals various positive implications and challenges that need to be considered. First of all, chatbots contribute greatly to learning efficiency. With its ability to provide quick answers and explanations that can be accessed at any time, chatbots can increase responsiveness to students' needs. This can reduce the waiting time for students to get help, allowing them to gain a faster understanding of the subject matter. In addition, chatbots can also be programmed to provide a personalized learning experience. By understanding student preferences and comprehension levels, chatbots can present learning content tailored to individual needs. This opens up the potential to address specific learning difficulties, provide additional practice, or provide needed reinforcement of concepts. However, these positive impacts are not without some challenges. The use of chatbots raises concerns about the loss of social interaction and humanizing aspects of learning. Students may miss the presence of teachers as mentors and facilitators who can provide emotional support and personal guidance. In addition, it is important to note the possible errors or limitations of chatbots in providing accurate and in-depth answers. While they can help at a basic level, they may not be able to fully replace the role of the teacher in providing a deep understanding of complex concepts.

The use of chatbots at Junior High School 1 Tigo Nagari has enhanced students' learning experience through natural language processing technology that aids understanding of subject matter. The chatbot eases communication, reduces teacher workload, and provides convenience for students to ask questions. However, there is a concern that over-reliance on chatbots may inhibit students' critical thinking skills, necessitating integration with teaching strategies that encourage critical thinking and independence. Recommendations include training for students and teachers, as well as monitoring and adjusting the use of chatbots through user feedback to maintain effectiveness and relevance. Future research could focus on the development of critical thinking skills using chatbots and their impact on learning outcomes and non-cognitive skills such as collaboration and time management. Further studies could also explore the integration of chatbots with other learning systems to create a more efficient and accessible digital learning ecosystem. Analysis of user preferences and interactions can help develop more personalized and relevant features. Thus, it is hoped that Junior High School 1 Tigo Nagari and other institutions can utilize the full potential of online learning to improve the quality of education.

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Evaluation of the practicality of project-based learning implementation plan in light vehicle engine maintenance using ADDIE approach

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ABSTRACT

Light vehicle engine maintenance is an important subject in automotive vocational education. However, several problems need to be overcome, such as the lack of student involvement in learning, which creates a gap between theoretical and practical learning. To overcome this problem, a project-based learning implementation plan (LIP) was developed which has been proposed as an approach capable of integrating theory and practice, as well as increasing student involvement in learning. This research aims to evaluate the practicality of product development in the form of a project-based LIP on light vehicle engine maintenance. This study uses an R&D approach as well as the ADDIE model procedure. The subjects in this study were 5 experts who came from productive teachers. The instruments used are interview sheets for observation activities and instruments in the form of response questionnaires to obtain product practicality data. The analysis technique at the practicality criteria level uses a practicality value formula in percentage form. The research results have found that the practicality of the product implementation plan for project-based learning in light vehicle engine maintenance learning is based on teacher responses which have been analyzed so that it is stated in the convenient category. This study concludes that the project-based lesson plan developed has high practicality in learning light vehicle engine maintenance. Further research can test the effectiveness of project-based learning implementation plans on a larger scale by involving more students and educational institutions and integrating modern technologies such as augmented reality or virtual reality into the learning implementation plans.

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INTRODUCTION

Developing a learning implementation plan (LIP) is an important aspect of designing an effective and efficient learning process. LIP acts as a guide for teachers in planning and organizing learning according to the needs and characteristics of students (Kaliisa et al., 2023). This concerns the professionalism of a teacher before teaching must-have tools and planning in the learning process

(Setiawan et al., 2020). Teachers are required to get ready learning instruments such as in planning lesson plans. LIP has various elements such as learning objectives, learning strategies, learning materials, assessments, and the steps that will be carried out in the learning process (Johnson et al., 2020).

The development of a good lesson plan involves a deep understanding of learning objectives, student needs, and appropriate learning approaches and strategies. Well-structured and organized lesson plans provide clear directions to teachers and ensure that all aspects of learning are covered systematically (Audina & Harahap, 2022). The importance of developing a good lesson plan lies in its ability to optimize the learning process and achieve the desired results (Masmin, 2020). Quality lesson plans will enable teachers to teach effectively, facilitate student understanding, and encourage the development of student's skills and understanding of concepts (Wibawa, 2019). In addition, lesson plans can also help teachers face challenges in learning, such as accommodating individual student differences, paying attention to student learning styles, and integrating technology into the learning process (Widiasih, 2021). LIP which is well developed can be an effective tool for achieving compatibility between learning objectives and student needs, as well as ensuring that learning takes place in a directed and meaningful way.

Based on the results of observations in the field, precisely at State Vocational School 1 Lahat (SMKN 1 Lahat), during an interview with the head of the light vehicle engineering department, it was found that the learning tools, especially lesson plans, had been used for a long time and this was certainly no longer suitable for the current characteristics of students. The LIP used in learning light vehicle engine maintenance has never been updated and still uses the old format with the learning methods used in the LIP in a conventional context. Even though this subject is one of the obligatory subjects that proceeds to develop.

Light vehicle engine maintenance is an important subject in automotive vocational education. The main problems often faced are the lack of student involvement and the gap between theory and practice in learning light vehicle engine maintenance at SMK Negeri 1 Lahat. Lack of student involvement is a significant obstacle (Farrow et al., 2024; Issa & Khataibeh, 2021). Many students feel bored or unmotivated because the teaching methods tend to be monotonous and do not involve direct activities. Learning that focuses on theory without giving students space to actively participate can reduce interest in learning (Almulla, 2020). To overcome this problem, a project-based lesson plan (LIP) has been proposed as an approach capable of integrating theory and practice, as well as increasing student involvement in learning.

Talking about the maintenance of light vehicle engines, with technological developments that are quite rapid, so special attention is needed to prepare plans in the learning process. An example of a case found is the use of this undeveloped lesson plan, learning activities that lack variety, are less creative, and are less innovative in the learning process. So, it was found that students were still less active, not focused, and lacked motivation to learn. LIP is very important to use and implement to motivate students and actively participate in the learning process (Solehuddin et al., 2022). In fact, for the current conditions of student characteristics, emphasis is needed so that learning is centered on students, not teachers anymore (Juniantari, 2017). With a paradigm shift like that, it is hoped that students will be more active, with motivation arising from the students themselves.

The development of project-based lesson plans in this subject is an innovative and relevant approach in the world of vocational education. In this era of rapid development of technology and the automotive industry, students need to have a strong theoretical understanding and relevant practical skills (Jalinus & Nabawi, 2017; Widawati, 2021). This approach also allows students to develop collaboration skills, problem-solving, and critical thinking (Hadi et al., 2017; Dewi et al., 2019). During project activities in this subject, students must work in teams, analyze problems, plan appropriate actions, and evaluate the work that has been done (Endrayanto et al., 2023; Huda et al., 2024; Utomo & Kurniawan, 2020). In addition, students will also be directly involved with light vehicle engine components, gaining a deeper understanding of the systems involved in maintenance (Ismael et al., 2024; Pane et al., 2022).

This research has a high urgency in improving the learning quality of light vehicle engine maintenance. By integrating theory and practice through project-based lesson plans, students will

have the opportunity to develop practical skills that are relevant to the real world (Muslim et al., 2020; Saputro & Rahayu, 2020). According to a report from the World Economic Forum (2023), industry requires a workforce that not only has theoretical understanding but is also able to apply knowledge in direct practice. UNESCO (2019) reported that countries with vocational education integrated with direct practice have a student success rate in transitioning to the world of work of 85%. In contrast, countries with a less integrated approach only reach 60%. In addition, this research can also overcome the gap that often occurs between theory and practice in light vehicle engine maintenance, so that students will be better prepared to face challenges in the automotive industry.

Previous research results have underscored the importance of student engagement in learning and the integration of theory and practice. According to Eliza et al, Laili et al and Marheni, it was found that the importance of involvement between students who are active in the learning process by using a learning model that is appropriate to the characteristics of students and is integrated both theoretically and practically (Eliza et al., 2019; Laili et al., 2019; Marheni, 2022). However, this research will provide a new contribution by focusing on the use of project-based LIPs. Looking at the practicality of project-based lesson plans, this study will complement previous research and provide more specific insight into the potential of project-based lesson plans in improving learning.

Based on the problems and solutions offered, the main aim of this research is to evaluate the level of practicality of project-based learning implementation plans (LIP) in the maintenance subjects described previously. This research will contribute to the novelty in automotive vocational education and provide new insights into the potential of project-based learning approaches that can be integrated into learning implementation plans.

METHOD

Practical activities for developing project-based learning implementation plans (LIP) with R&D research using the ADDIE model development procedure. The ADDIE model is a systematic framework or approach used to design, develop, and evaluate learning or training programs. The stage in the analysis phase involves identifying learning objectives, needs analysis, student characteristics, and challenges in learning as well as reviewing literature regarding project-based lesson plans. The design stage is designing the lesson plan by determining the competencies that will be achieved by students in this subject, preparing the structure of the lesson plan, and important elements such as learning objectives, learning activities, learning materials, assessments, and project activity steps. The development stage is the process of producing or creating learning materials, such as modules, videos, presentations, or other aids. All elements designed in the previous stage are realized in real form. The implementation stage involves the implementation of learning or training. The developed material is delivered to the target audience. The implementation process also includes ensuring that all resources are ready to use. The evaluation stage is carried out to assess the success of the learning program.

Before being implemented in the field, the product in the form of a lesson plan needs to undergo several stages of development. The development stage in question is product development (Rusmanto & Rukun, 2020). This research is at the practicality stage, where the product in the form of lesson plans will be evaluated and the level of practicality to be used will be sought. The understanding of this practical category is that the product being developed has a level of use. This is done by conducting direct trials on products that have been developed previously (Juniantari et al., 2020; Muslim et al., 2023; Suharti et al., 2020). LIP is said to be practical after the instrument that has been distributed is in the form of a teacher response questionnaire with a level of data interpretation in practical conditions or very practical to use.

The development stage has been carried out by developing the product with the previously designed design. This is done of course after evaluating at the previous stage. This is following the development procedure using the ADDIE model which can be seen in Figure 1. Revise and adjust the LIP based on feedback from experts who have provided validity values for this product. After getting the validity value and carrying out revisions, the stage that must be carried out is the implementation stage by distributing practical instruments in the form of teacher response questionnaires.

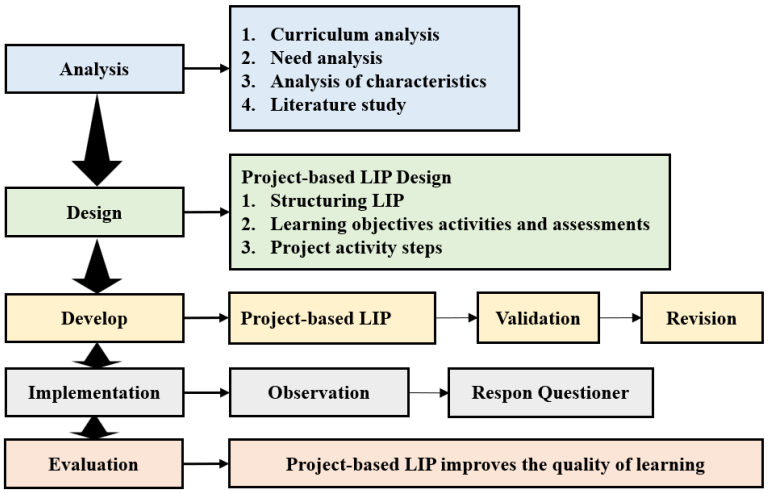


Figure 1. ADDIE Procedure

The implementation stage will also include conducting direct trials in the field to obtain effectiveness values. Limited trials were conducted at State Vocational School 1 Lahat in the odd semester of 2023/2024, while the sample for this study was 30 students majoring in light vehicle engineering at the vocational school. The sampling technique used was cluster sampling by randomly selecting 3 existing classes. This effectiveness value is viewed from classical completeness based on learning outcomes tests using one-shot case study analysis techniques and interpreted using the classical completeness criteria table (Syah, 2019). The evaluation stage is a series of evaluations used at each stage in the ADDIE model, which is the final result of the first stage and the beginning of the next stage. The stages in this model allow researchers to design, implement, and evaluate project-based lesson plans comprehensively and effectively.

This research uses a descriptive quantitative approach in presenting data and interpreting practical data on project-based LIPs. The instrument used in this research is a practicality questionnaire or response questionnaire. The response questionnaire has passed the eligibility test first and is declared valid as a practical instrument with an average validity value given by experts of 87.5%. The response questionnaire instrument grid can be seen in Table 1.

Table 1. Response Questionnaire Instrument Grid

No.	Aspect	Indicator
1.	Appearance	LIP Components Comply with Process Standards
		Identity is by Reference Standards
2.	Presentation	There is an Implementation Plan
		Planning in Classroom Management
		Planning the Use of Process Standards in Learning
		Assessment Plan for Learning Purposes

The subjects of this research were five light vehicle engine maintenance teachers who had teaching experience in this subject. The selection of teachers as research subjects aims to gain rich and varied insights into the practicalities of product development. After getting data from the instruments that have been distributed, carry out an analysis to get the overall percentage by applying the practicality value Formula 1 (Trianto, 2014).

$$P = \frac{R}{SM} \times 100\% \quad (1)$$

P is the practicality score, R is the total score obtained, SM is the maximum score. The average percentage will be interpreted into the data interpretation Table 2 (Purwanto, 2011) for the level of practicality to provide final results that can be concluded.

Table 2. Practicality Category

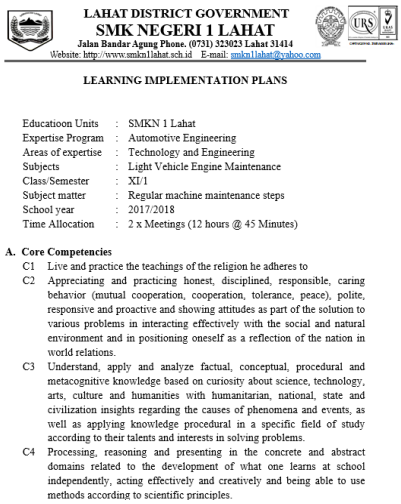
No.	P	Kategori
1	80% - 100%	Very Practical
2	60% - 79%	Practical
3	40% - 59%	Quite Practical
4	20% - 39%	Less Practical
5	0% - 19%	Not Practical

RESULTS AND DISCUSSION

Results

The results of the analysis phase after identifying learning objectives, student characteristics, and challenges and reviewing the literature, it is necessary to develop lesson plans with a learning approach that can encourage students to be more active in learning. Not only active learning but there is also collaboration with colleagues and being able to apply it to real conditions. Based on this, a project-based learning approach is used which has been integrated into the lesson plan design. The design phase is carried out after going through the analysis phase by evaluating the end of the analysis step. Based on the final results of the analysis phase, the next stage is to design a project-based LIP. This is done by determining the competencies achieved in the subjects, compiling the structure of lesson plans, and important elements such as learning objectives, learning activities, learning materials, assessment, and project activity steps.

The next stage is the development of a project-based LIP. At this stage, the product has been developed and passed the feasibility aspect commonly known as validity. After making revisions according to expert advice in the form of adding time allocation in each learning phase to the core activities and several reference sources that can be taken from the internet, the next stage is product implementation on research subjects. The appearance of the product that has been developed can be seen in Figure 2 and this has also been presented in Table 3 and Table 4. Figure 2, is the initial view of the product in the form of a project-based LIP that has been developed. This section explains the header display section according to the format used by the school where the research is conducted. This section also presents educational units, skills programs, areas of expertise, subjects, classes, main material, and time allocation and also presents the core competencies that students will complete later. Table 3 is a display of basic competencies and indicators that will be implemented later in class. Table 4 is the introductory, core, and concluding parts of an LIP that was developed. This section also describes the activities accompanied by the time allocation used. The core activities developed are by the phases of the project-based learning model, starting from the first phase to the sixth phase, which begins with basic questions and ends with an experience evaluation.



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LEARNING IMPLEMENTATION PLANS

Educatioon Units	:	SMKN 1 Lahat
Expertise Program	:	Automotive Engineering
Areas of expertise	:	Technology and Engineering
Subjects	:	Light Vehicle Engine Maintenance
Class/Semester	:	XI/1
Subject matter	:	Regular machine maintenance steps
School year	:	2017/2018
Time Allocation	:	2 x Meetings (12 hours @ 45 Minutes)

A. Core Competencies

C1 Live and practice the teachings of the religion he adheres to

C2 Appreciating and practicing honest, disciplined, responsible, caring behavior (mutual cooperation, cooperation, tolerance, peace), polite, responsive and proactive and showing attitudes as part of the solution to various problems in interacting effectively with the social and natural environment and in positioning oneself as a reflection of the nation in world relations.

C3 Understand, apply and analyze factual, conceptual, procedural and metacognitive knowledge based on curiosity about science, technology, arts, culture and humanities with humanitarian, national, state and civilization insights regarding the causes of phenomena and events, as well as applying knowledge procedural in a specific field of study according to their talents and interests in solving problems.

C4 Processing, reasoning and presenting in the concrete and abstract domains related to the development of what one learns at school independently, acting effectively and creatively and being able to use methods according to scientific principles.

Figure 2. Initial Appearance and Core Competencies of Project-Based LIP

Table 3. Display of Project-Based LIP Basic Competency

No.	Basic Competencies
1	1.1 The Environment and Natural Resources as Gifts from Almighty God must be Preserved and Preserved Forever
	1.2 The Development and use of Technology in Learning Activities must be in Harmony and not Damage and Pollute The Environment
2	2.1 Demonstrate a Caring Attitude Towards the Environment Through Activities Related to Light Vehicle Engine Maintenance
	2.2 Demonstrate a Careful and Thorough Attitude in Maintaining Light Vehicle Engines
	2.3 Demonstrate Discipline and Responsibility in Carrying Out Light Vehicle Engine Maintenance by SOP
	2.4 Demonstrate a Careful and Caring Attitude Towards Work Safety
	2.5 Demonstrate a Caring Attitude Towards the Environment Through Activities Related to Light Vehicle Engine Maintenance
3	3.1. Understand how to Maintain Machines Regularly
	Indicator
	1. Students can Explain the Meaning, Purpose, and Requirements for Periodic Maintenance or Servicing of Motor Vehicles
	2. Students can Prepare, use, and Maintain the Workplace and Carry Out Periodic Maintenance According to the Correct Procedures
	3. Students can Lift Various Types of Vehicles Safely and According to Correct Procedures
	4. Students can Clean the Outside and Inside of the Vehicle According to the Correct Procedures
4	4.1. Maintain the machine regularly
	Indicator
	1. How to Maintain the Machine Regularly
	2. How to Adjust the Timing Belt

Table 4. Displaying the Introduction, Core, and Closing Parts of the Lesson Plan

No.	Activity	Description (Indicator)	Allocation (minutes)
1	Introduction Step	1. Opening in Class	20
		2. Pray	
		3. Sing the National Anthem	
		4. Absence	
		5. Provide Motivation to Students in Learning	
		6. Provide Initial Problems	
2	Core Step	**Exploration**	
		Delivery of Objectives and Competencies Mastered	20
		Elaboration	
		Phase 1: Determining the Fundamental Questions	15
		Phase 2: Design Project planning	15
		Phase 3: Arranging a Schedule	15
		Phase 4: Student Monitoring	120
		Phase 5: Testing Results	15
		Phase 6: Evaluating Experience	30
3	Closing Step	Concluding, Evaluating, and Preparing to Go Home	20

Following the research method, where the research subjects for product trials in obtaining practicality criteria were 5 productive teachers majoring in automotive engineering. The response questionnaire that had been prepared was then distributed to 5 experts to obtain practical value for the product. The results of filling out this response questionnaire can be seen and understood in Figure 3. In this figure, it is explained that 2 aspects are assessed of the product that has been developed, namely the display aspect and the presentation aspect.

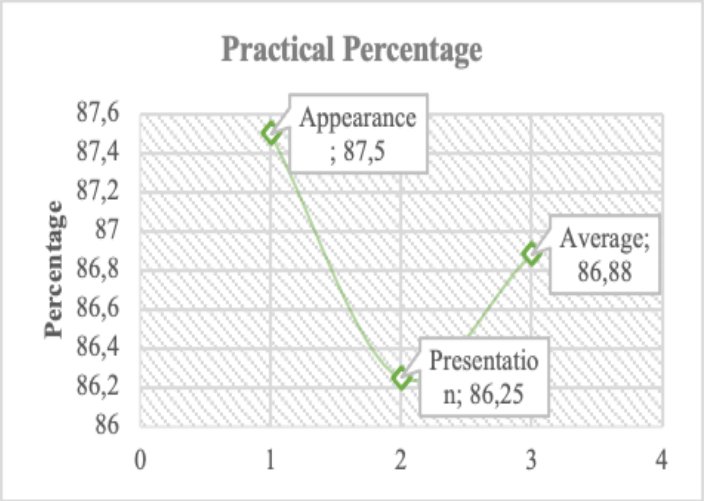

Figure 3. Percentage of Practicality from the Aspect of Appearance and Presentation of the Project-Based LIP

Based on the results of the practicality test on the product being developed, the data obtained for appearance obtained a value of 87.5%, and presentation of 86.25% so the average analysis percentage obtained was 86.8%. After obtaining the percentage value from the research instrument, the next step is to interpret the data in the product practicality interpretation table. The final result obtained is a product developed in the practical category.

Discussion

The results obtained from developing this project-based LIP are practical values. The results obtained are an in-depth understanding of product development. The product developed was implemented in one of the subjects in the light vehicle engineering department at SMKN 1 Lahat. The practicality of the product being developed is by product development principles in the form of project-based lesson plans on the subject of light vehicle engine maintenance.

The practicality test was carried out with the help of responses from productive teachers majoring in light vehicle engineering, resulting in a product in the very practical category with an average score of 86.88%. This means that this product is following what it is supposed to serve. In line with Brand (2020), Ko et al (2021), and Xu et al., (2022) stated that by developing a product if procedures or steps and methods are used in the right direction, the result that will be obtained is a practical product. According to Lindorff et al., (2020), Meika et al., (2019), and Rombout et al., (2021) stated that based on the appearance and presentation aspects taken from the response questionnaire instrument if it is developed using good correct procedures, it will produce a product that is practical to implement.

Hufri et al., (2019) stated the importance of presenting content that is easy to use and utilizes the product. In addition, teacher involvement in the product development process increases the practical value of the product (Panggabean et al., 2021). This has been done in this study which is a positive assessment to achieve a high practicality value. The high level of practicality in the appearance aspect shows that the product can attract the attention of students who are generally more responsive to visualization. Meanwhile, the high presentation value emphasizes that this product is not only attractive but also able to provide effective learning guidance.

The LIP developed is oriented towards active learning that allows students to be directly involved in projects that are relevant to real conditions. This approach motivates students to learn more deeply which can connect theoretical concepts with practical applications directly. Practicality testing by directly involving teachers in providing an overview of this product can be applied in class. This shows that the project-based approach is acceptable to teachers and students so that it is easy to adopt in learning activities.

Products developed in the form of lesson plans also have a significant impact on student involvement in learning light vehicle engine maintenance. These results or findings are in line with

research activities that have been completed previously, which show that the integration of project-based learning in lesson plans or learning tools that are developed will increase student involvement, students are motivated and there is interest in solving problems given by the teacher so that they can find solutions on real projects (Lin, 2018; Lin et al., 2021; Syamsuri et al., 2017). Student involvement in real projects provides additional motivation and provides opportunities to develop collaboration and problem-solving skills (Jiang, 2021; Muslim et al., 2021; Sugiarto et al., 2023).

Through project-based LIP, students can apply theoretical knowledge in light vehicle engine maintenance in a real context. The results showed that student's understanding of concepts increased through implementing the concepts in projects. These findings support previous research which shows that project-based learning can increase the level of understanding of learning concepts by connecting theoretical and application learning activities through practical activities (Almulla, 2020; Baghoussi & El Ouchdi, 2019).

The findings of this research support the view that active, contextual, and practice-integrated learning provides a more meaningful and in-depth learning experience for students. According to Veza (2021), active learning will become a benchmark so that learning abilities increase. The benchmark for students' abilities can be seen from the learning process, learning innovation, and the teacher's ability to organize the learning process (Anwar et al., 2022; Hidayat et al., 2020; Syahril et al., 2022).

These findings provide a strong theoretical and pedagogical foundation for applying a project-based learning approach to light vehicle engine maintenance subjects at State Vocational School 1 Lahat. The findings of this research provide clear direction for automotive vocational education in improving the quality of learning and preparing students with relevant skills to face the challenges of the world of work. This is in line with Penuel et al., (2011), the development and testing of innovations in implementing learning implementation plans will improve the quality of learning.

Project-based lesson plans provide students with the opportunity to develop relevant practical skills in this subject. The research results show that students can apply practical skills, such as problem-solving, conducting analysis, and planning appropriate actions in maintenance projects. These findings support previous research which shows that project-based learning can increase students' practicum scores in the skill level category in applying theoretical knowledge (Aydın et al., 2018; Eliza et al., 2017; Marten et al., 2019).

Through the use of project-based lesson plans, students are actively involved in learning, develop relevant practical skills, and deepen their understanding of concepts. With the involvement of students in real projects, they can develop practical skills needed in the world of work (Mali, 2016; Gerhana et al., 2017). This helps students prepare for success in their careers in the automotive industry.

Students become active in problem-solving, collaboration in teams, and analysis of problems (Adawiah et al., 2014; Jalinus et al., 2022; Sukmasari & Rosana, 2017). With high involvement, students can build a strong interest in the subject and feel more involved in the learning process (Dwiyanti & Rosana, 2020; Saputra et al., 2021). Students can apply theoretical knowledge in the context of real light vehicle engine maintenance. This helps students deepen their understanding of basic concepts and develop relevant practical skills (Hidayati et al., 2017).

Based on the results of this research, it can be interpreted that the development of this product has a positive impact on increasing student engagement, conceptual understanding, and practical skills. Project-based lesson plans provide contextual and real-world relevant learning experiences, which help students effectively connect theory with practice. The practical implication is the importance of implementing a project-based learning approach in light vehicle engine maintenance, especially in the light vehicle engineering department at State Vocational School 1 Lahat to improve the quality of learning and prepare students with relevant skills to enter the automotive industry.

There are several limitations in this study, one of which is regarding the time and condition of the curriculum that continues to change. Project-based learning requires a longer time in the application process in the field. The dense curriculum conditions will create difficulties in implementing previously planned projects. Other limitations are limited trials and the number of teachers at State Vocational School 1 Lahat. In addition, this study emphasizes more on the practical

aspects of the products developed. The direct impact and involvement of students and their practical improvements have not been studied directly. Further research is needed on the advantages and disadvantages of presenting this project-based lesson plan so that application in the field can be carried out optimally.

CONCLUSION

The conclusion that can be presented regarding the results of this research is that the development of a project-based learning implementation plan (LIP) on the subject of light vehicle engine maintenance has high practicality. The teacher's role as an instructor provides a positive response to the application of the product being developed. The results of LIP development are still focused on the practical level of productive lecturers and teachers at the secondary education level. Further research can be conducted by evaluating the effectiveness of the project-based learning implementation plan on a larger scale involving more students or other educational institutions. In addition, in-depth research can be conducted by integrating interactive learning technologies such as the use of augmented reality or virtual reality to increase student engagement.

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Dinggo Sedaya website: Innovation in digital learning resources for early children's education

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ABSTRACT

Digital learning resources aim to be a container or reference that can be used as a support to develop existing learning tools. In addition, current technological advances make learning resources one of the containers that can improve digital literacy competencies for its users. Technology mastery skills are key in utilizing digital technology. However, it is unfortunate that digital learning resources are not utilized properly due to limited technology usage skills, especially in learning. In addition, the lack of digital learning resources for early childhood education is one of the limitations in adjusting digital learning resources for Early Childhood Education teachers. This study itself aims to create an efficient, effective, and attractive website product to be used as a digital learning resource for in-depth early childhood education. Data collection methods used include interviews, observations, and filling out questionnaires. This study uses the Research and Development (R&D) method by implementing the ADDIE design. The sample in this study was thirty Early Childhood Education teachers. The results of the study showed that the Dinggo Sedaya website is suitable to be used as a digital learning resource for in-depth early childhood education. Based on the results of validity and feasibility, the Dinggo Sedaya website is valid and suitable for use. This study implies that the Dinggo Sedaya website can be accessed by teachers as a digital learning resource for developing learning tools and improving the digital literacy competencies of Early Childhood Education teachers. Further research is expected to be able to examine the development of digital learning resources more broadly to provide a comprehensive picture and become the basis that digital learning resources need to be developed to support more meaningful learning in early childhood.

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INTRODUCTION

Information and communication technology is one of the transformation elements in the educational structure in contemporary times. Advances in information technology in the learning process can be simulated more authentically and can be understood using various methods by students (Juniarti & Gustina, 2019). The use of information technology is currently widely available on various platforms as an effort to improve the quality of the learning process. Regarding early childhood education, the current task of educators has a crucial significance in producing a

substantial learning process. Mastery of these competencies is anticipated to increase educators' creative power in realizing learning activities, children's academic achievements, and educators' professional growth which will have an impact on a high level of educational quality (Ismawan et al., 2020).

One way to master these competencies is for teachers to utilize information technology as a learning resource in developing learning tools (Szymkowiak et al., 2021; Wu et al., 2022). Teachers have an important role in supporting learning, including in early childhood education. The development of the modern era currently provides positive support that utilizing digital learning resources can improve the quality of learning (Elumalai et al., 2020). However, the use of technology in early childhood requires expertise to integrate safe and appropriate technology. Teachers act as sorters of learning resources according to children's development in increasing their creativity (Li & Wang, 2022; Wong et al., 2021). Teachers must also be able to integrate technology into learning methods to improve children's growth and development according to the times. This makes the important role of teachers in utilizing digital-based learning resources in learning (Kharismatunisa, 2023; Nurhayati et al., 2024).

However, in its implementation, there are still many educators who have not optimized the use of learning resources with digital technology. This was also expressed by Zyuro & Komalasari (2020) that Childhood Education program teachers still often experience problems in preparing learning tools and using technology. Even though teachers have the main components in designing, implementing, and evaluating each learning activity using methods and media as determinants of the success of the learning process carried out (Putra, 2022). This phenomenon is one factor that causes the lack of digital literacy skills in Childhood Education program teachers (Hardiyanti & Alwi, 2022). Digital learning resources regarding early childhood education are also still limited (Sutama et al., 2021). Educators perceive that the availability of learning resources in special education institutions is still very limited, making digital learning resources inaccessible. Based on the results of observations in using technology, 18 out of 30 Early Childhood Education Teachers Cluster 1 in Kedungkandang Village have not been able to understand and utilize features that can be used as digital learning resources for children. This is because digital learning resources specifically for early childhood are still limited and many find it difficult to access existing platforms, so teachers often do not utilize digital learning resources in developing classroom learning. This situation means that learning resources, especially for early childhood, need to be further developed so that they can make it easier for teachers to access and implement them in learning. This situation is necessary to develop digital-based learning resources that make it easy for users to apply so that they can be accessed universally and flexibly via a website (Gabriel et al., 2022; Huda, 2023).

The novelty of this study focuses on the development of digital-based learning resources for early childhood education that can be utilized by teachers in developing learning. Similar research has been reviewed by Koesmadi et al., (2024) that the use of websites can be a digitalization strategy for the implementation of Childhood Education Programs-HI with five essential child needs services. The study only focuses on the development of digitalization at the Early Childhood Education Programs level, so this study provides innovation through the development of website-based digital learning resources for early childhood education by developing learning materials that can be adjusted to aspects of child development. Through the development of this website, it becomes an innovation in integrating digital learning resources that can be applied to early childhood learning.

This research will examine the management of digital learning resources that can be adjusted to aspects of early childhood development. In addition, this research also offers development with practical methods so that teachers can utilize digital learning resources effectively because they provide ease of use. The convenience and adjustment based on aspects of child development are the novelties of this research from previous research.

METHOD

The Study This use method of study Research and Development (R&D) aims To make a product new as well as do testing on the product. This matters because, with the use of technique,

researchers can identify and create something more products interesting and useful For the public in general, esp in the scope of educating children early. Application mandatory procedures taken in making something products, research This using the ADDIE procedural model. Stages in study development include: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Sugiyono, 2022). The ADDIE development model is presented in Figure 1. Stages research and development Dinggo Sedaya website explained as follows:

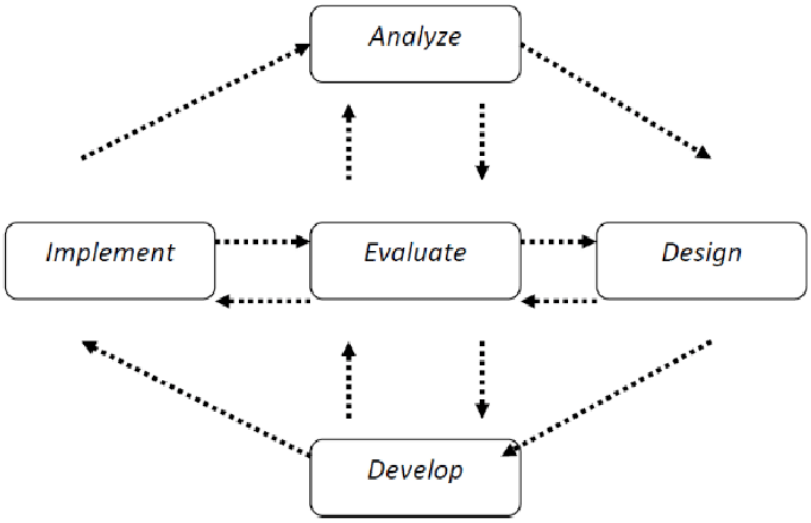

Figure 1. ADDIE Method Stages

Analysis

Planning media development in research This is done through stage-related analysis with desired media needs developed. Analysis carried out in studies development This consists of analysis need For study problem basics that occur in learning as well as study needs in development learning, as well analysis material covered identification of teacher needs so relevant to the media that will be developed. In research development, analysis of teachers' needs is carried out based on needs development learning through source study accordingly with need digital-based for Early Childhood Education Teachers Cluster 1 Kedungkandang, Malang City. Achievements used in the development Dinggo Sedaya website, namely teachers can operate a website as a reference source for digital learning for children's education age early.

Design

Stages second in study development This is design (planning). Stages This is done after analyzing problems already found with designing the product that will created, ie designing a use case diagram on the Dinggo Sedaya website. Use case diagrams are depiction-type interactions between the user of a program (system) with the system alone. Use case diagrams utilized as form depiction between actors with a function that will executed.

Development

Stage third in study development is development. Media development is carried out in four stages that is media development in the form of website, creation instrument assessment, validation products, and media revisions. For four stages of ongoing development are detailed as follows.

1. Media Development in the form of Website
   At this stage, this is done by making website nature dynamic and easy operated in accordance with need. The website page contained on page homepage, guide usage, projects, news, as well a page about us. The content of every existing page is customized with analysis needs and analysis material obtained from the analysis and design stage.

2. Making Instrument Evaluation
   The development of evaluation instruments in this study was carried out before the data collection process in the form of questionnaires. At the stage of making assessment instruments which includes validation of instruments by experts to assess the attractiveness, effectiveness, and efficiency of the products developed. The evaluation instruments are adjusted to the predetermined grid. The grid for making the instrument is presented in Table 3, Table 4, and Table 5.
3. Validation Product
   This stage is carried out after the creation of the instrument, namely conducting media validation and testing the practicality of the media by media experts and material experts. Media validation is carried out based on an instrument in the form of a questionnaire for media experts, material experts, and users.
4. Media Revision
   At this stage, this held repair product after validated and tested eligibility based on suggestions and input so that the produced product from the Dinggo Sedaya website is ready implemented and tested by the user.

Implementation

Stage 4 in study development This is the implementation of the Dinggo Sedaya website to users. Stage implementation is also used For test media appropriateness when implemented by teachers as users. Try out The Dinggo Sedaya media website will applied twice, namely to groups small and group big. The trial group will involve 8 Early Childhood Education Teachers in Cluster 1 Kedungkandang, Malang City. Furthermore implementation group big will involve all teachers of Early Childhood Education Teachers Cluster 1 Kedungkandang, Malang City. After doing a test run for each group, the teacher is asked To fill in a questionnaire to obtain information about media validity as well as know will problems in the subsequent use of the media revised To find results good product.

Evaluation

The final stage in preparation of the ADDIE model is stage evaluation. This process involves enhancement as well as adjustment toward existing media. At a stage, this can also be done in the fourth stage previously named evaluation formative which is purposeful evaluation as repair as soon as possible. At stage this, evaluation to use editing or improvements to existing media designed with the objective get a superior product can applied to reach the objective expected research. Evaluation is done after testing group large amount carried out by users (teachers).

Table 1. Observation Grid

No.	Observed Aspects
1.	Research with Teachers using Digital Learning Resources
2.	Research with Children using Digital Learning Resources Implemented by Teachers
3.	Children's Enthusiasm for Learning by Using Digital Media
4.	Teacher's Ability to Operate Digital Learning Resources
5.	Teachers' Difficulties in Operating Digital Learning Resources

Table 2. Interview Grid

No.	Indicator	Question Topic
1.	Teacher Analysis	Problems Experienced by Teachers
		Hope for the Future
2.	Need Analysis	Availability of Digital Learning Resources
		Intensity of use of Digital Learning Resources
		Problems Regarding Digital Learning Resources
		Hope for the Development of Digital Learning Resources

Table 3. Material Expert Validation Instrument Grid

No.	Aspect	Indicator	No. Item
1.	Attractiveness	Accuracy of Writing	1,2
		Sentence Accuracy	3,4,5
		Website Appearance	6,7
2.	Effectiveness	Material Suitability	8,9,10,11
		Material Coverage	12,13,14,15,16

(Setyadi & Qohar, 2017)

Table 4. Media Expert Validation Instrument Grid

No.	Aspect	Indicator	No. Item
1.	Attractiveness	Website Design	1,2
		Writing	3,4,5
		Color	6,7
		Picture	8,9,10
		Layout	11,12
		Language	13,14
2.	Effectiveness	Collapse	15,16
		Completeness	17,18,19
		Convenience	20,21,22
		Utility	23,24

(Setyadi & Qohar, 2017)

Table 5. User Validation Instrument Grid (Teacher)

No.	Aspect	Indicator	No. Item
1.	Attractiveness	Website Design	1, 2
		Writing	3, 4, 5
		Color	6, 7
		Picture	8, 9, 10
		Layout	11, 12
2.	Effectiveness	Accuracy of Words	13, 14
		Sentence Accuracy	15, 16
		Material Suitability	17, 18, 19, 20
		Material Coverage	21, 22, 23, 24, 25
3.	Efficiency	Completeness	26, 27, 28, 29
		Convenience	30, 31, 32
		Utility	33, 34

(Setyadi & Qohar, 2017)

Research analysis methods development This consists from analysis qualitative and analysis quantitative. The analysis will used to evaluate results including results observations, interviews, and input in the form of critics or advice from experts or users such as material repair Dinggo Sedaya website media products, data obtained Then will analyzed in a way descriptive. Whereas technique quantitative data analysis form questionnaire validity and practicality. Questionnaire validity is addressed by expert materials and media, meanwhile questionnaire practicality for teachers as users. The assessment instrument is a questionnaire submitted to material experts, media experts, and users using the Likert scale listed in Table 6.

Table 6. Likert Scale

No.	Score	Evaluation
1	1	Very Good
2	2	Good
3	3	Not Good
4	4	Very Not Good

(Sugiyono, 2022)

The achievement results obtained will be converted into percentages using the conversion method using the Formula 1 from (Akbar, 2013).

$$Vah = \frac{Tse}{Tsh}\ x\ 100 \quad (1)$$

Information :
Vah = Expert validation
Tse = Total score obtained
Tsh = Maximum total score
100 = Constant

The results obtained from the validation of material and media experts were then adjusted to the validation criteria for the Dinggo Sedaya website. Media validity criteria can be seen in Table 7.

Table 7. Dinggo Sedaya Website Validation Criteria

No.	Level of Achievement	Category	Test Decision
1	0% - 20%	Very Uninteresting	Can not be used
2	21% - 40%	Not Attractive	Can not be used
3	41% - 60%	Less Attractive	May be used with Major Revisions
4	61% - 80%	Quite Interesting	May be used with Minor Revisions
5	81% - 100%	Very Interesting	Used without Revision

(Akbar, 2013)

Website as a digital teaching material for early childhood education is considered successful and can be used as a digital teaching resource if it meets the standards set to be very effective, efficient, and attractive with the criteria of 81% - 100%, the Dinggo Sedaya website is said to be very suitable to be tested.

RESULTS AND DISCUSSION

Results

The results of this development research discuss two main things, namely describing the design of the Dinggo Sedaya website as a digital learning resource for early childhood education, and describing the validity of the Dinggo Sedaya website product as a digital learning resource for early childhood education. The design and development of the Dinggo Sedaya website uses the ADDIE model which consists of five stages. The first stage is the analysis stage. This stage aims to analyze needs and material analysis. The analysis stage was carried out by carrying out observations and interviews with Early Childhood Education Teachers Cluster 1 Kedungkandang Village, Malang City. The needs analysis was obtained based on the results of observations carried out at Kindergarten ABA 29 and Kindergarten ABA 20, Malang City. The results showed that teachers often experienced problems in using technology, this was because the features of digital-based learning resources could not be operated by Early Childhood Education teachers. This observation is strengthened by findings from interviews that have been carried out regarding teachers' problems and needs in meeting learning needs in early childhood learning. Based on the results of interviews with the Head of Early Childhood Education Teachers Cluster 1 Kedungkandang District, Malang City, several problems were found, namely teachers complaining about the limitations and ease of accessing digital-based learning resources, the lack of digital learning resources for early childhood education, and the lack

of teacher skills in utilizing digital technology. Material analysis was obtained from the results of interviews with Early Childhood Education Teachers Cluster 1 Kedungkandang Village, Malang City, which resulted in teachers needing learning resources as reference materials that can be applied in education for preschool-age children that are by the dimensions of growth and development. Apart from that, the teacher also explained that Early Childhood Education Programs learning by applying technology-based media makes children more enthusiastic about learning.

The second stage is the design (planning) stage. At this stage, product planning is carried out to be developed by the results of the needs analysis and material analysis. The planning stage is very important so that at the development stage you can produce a product that meets your needs and has a clear plan. This stage is carried out by designing the product that will be made in the form of a use case diagram on the Dinggo Sedaya website. Use case diagrams are the desired operational representation of a system (Maya, 2019). This diagram is used to map system requirements and present interactions so that you can understand the product design according to its functionality. The Dinggo Sedaya website can be accessed by users and administrators. On this website, users can only access the website with read (view) functionality, while administrators have more complex functionality, namely being able to create, read, update, and delete (CRUD). The functionality on this website can be used to access the Dinggo Sedaya website which contains the home page, guidebook page, news page, project page, and about us page. The news and project pages are equipped with a search feature to provide the ease of search needed by users. The project page is divided into categorizations which include media, materials, and methods that can be adapted to the child's growth dimensions which include moral and ethical dimensions, social interaction, knowledge capacity, movement ability, and artistic expression. This website also contains a user manual which can make it easier for users to operate the Dinggo Sedaya website. The About Us page contains the identity of the Dinggo Sedaya website developer as a media publication. As for the use plan case diagram as a design illustration on the website in Figure 2.

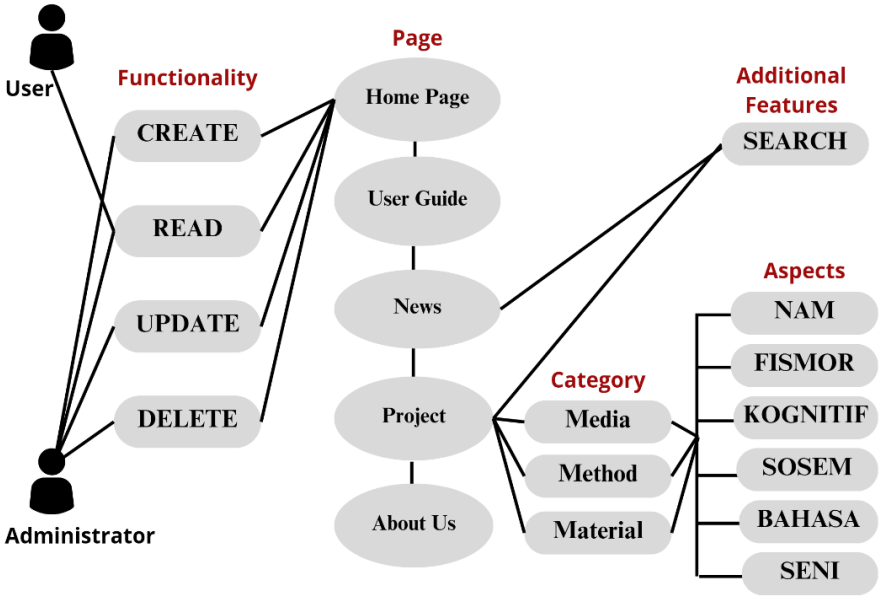

Figure 2. Use Cases Diagram Dinggo Sedaya Website

The third stage is the development stage. At this stage, the Dinggo Sedaya website was developed based on a design adapted to the needs analysis. In this phase, evaluation instruments are also developed, product validation by experts, and media revisions. The media development in the form of the Dinggo Sedaya website was developed according to needs, consisting of five pages, namely the home page, user guide page, project page, news page, and about us page. The development of content on this website is also adapted to material analysis, namely related to material about early childhood on the news and project pages. The results of the development of the Dinggo Sedaya website are presented in Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7.

Figure 3. Home Page

Figure 4. User Guide Page

Figure 5. News Page

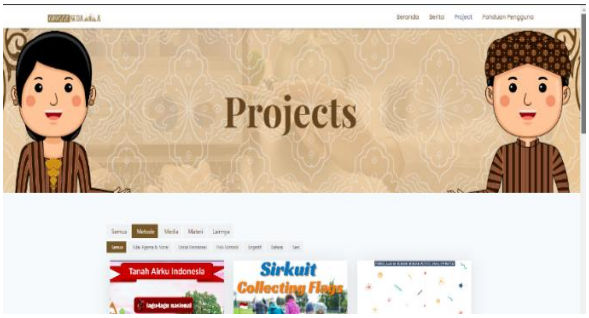

Figure 6. Project Page

Figure 7. About Us Page

This development process also involves preparing a validation tool that is evaluated by material experts, media experts, and users. The validation preparation is adjusted to the instrument guidelines that have been designed. The validation tool for material experts created has two assessment dimensions, namely attractiveness, and effectiveness, the media expert validation instrument developed consists of two aspects, namely attractiveness and efficiency, while the user validation instrument consists of three assessment aspects, namely attractiveness, efficiency, and effectiveness. Next, a validation test of the Dinggo Sedaya website product was carried out by material experts and media experts to determine the suitability of the website product by conducting an assessment based on a questionnaire. The results of the feasibility test for developing the Dinggo Sedaya website as a digital learning resource for early childhood education are presented in Table 8.

Table 8. Percentage of Dinggo Sedaya Website Feasibility Test Results

No.	Product Assessment Results	Percentage	Category
1.	Materials Expert	98%	Very Eligible
2.	Media Expert	96%	Very Eligible

The fourth stage in this development research is the implementation stage. At this stage, media is implemented in the form of the Dinggo Sedaya website which has been developed as a digital learning resource for early childhood education. This implementation was carried out by Early Childhood Education Teachers Cluster 1 Kedungkandang Village, Malang City. At this stage, two trials were carried out, including a small group trial and a large group trial. Small group trials were carried out in eight institutions including Cluster 1 of Kedungkandang Subdistrict, each institution involving one teacher as a small group trial. This trial begins with providing a guide to using the website, then the teacher as the user operates the website according to the existing guidelines. After the teacher can operate the website, the teacher is given a questionnaire to assess the level of validity of the website in terms of three aspects, namely effectiveness, efficiency, and attractiveness. The percentage of small-group trial results is presented in Table 9.

Table 9. Accumulated Total of Small Group Trials

No.	Assessment Aspects	This	Tsh	P%
1.	Aspects of Attractiveness	345	384	90%
2.	Effectiveness Aspects	465	416	88%
3.	Efficiency Aspect	259	288	90%
Total Score		**969**	**1088**	**89%**

Analysis of the data calculated using the formula above obtained a value of 89%. These results are in line with the eligibility criteria table from Akbar (2013), where if the achievement level reaches 81% - 100%, then you get the Very Eligible category. After carrying out small group trials and getting the Very Eligible category, the next stage is carrying out large group trials. The purpose of the large group trial is to see the attractiveness, effectiveness, and efficiency of the Dinggo Sedaya website. Large group trials were carried out in eight institutions including Early Childhood Education Teachers Cluster 1 Kedungkandang Village, Malang City, with 22 Early Childhood Education Teachers participating. The results of large group trials regarding aspects of effectiveness, efficiency, and attractiveness of the Dinggo Sedaya website media are presented in Table 10.

Table 10. Accumulated Total for Large Group Trials

No.	Assessment Aspects	This	Tsh	P%
1.	Aspects of Attractiveness	926	1056	88%
2.	Effectiveness Aspects	983	1144	86%
3.	Efficiency Aspect	688	792	87%
Total Score		**969**	**2597**	**87%**

The results of data analysis calculated using the formula obtained a value of 87%. These results are in line with the eligibility criteria table from Akbar (2013), where if the achievement level reaches 81% - 100%, then you get the Very Eligible category. Based on the results of large group trials by users, several deficiencies were found, so revisions were needed based on suggestions and input. Input for media improvements from users, namely the completeness of each project according to the stage of development so that many variations can be implemented and expanded by educators in their use. The fifth stage is the evaluation stage. At this stage, the overall test results obtained on the Dinggo Sedaya website that has been developed can be declared valid according to material experts, media experts, and users. The recapitulation results of the Dinggo Sedaya website feasibility test according to experts and product trials are presented in Table 11.

Table 11. Data from Assessment Results of the Dinggo Sedaya Website as a Digital Learning Resource for Early Childhood Education

No.	Product Assessment Results	Percentage	Category
1.	Materials Expert	98%	Very Eligible
2.	Media Expert	96%	Very Eligible

No.	Product Assessment Results	Percentage	Category
3.	Small Group Test	89%	Very Eligible
4.	Large Group Test	87%	Very Eligible
Total		**370%**	
Average		**92.5%**	**Very Eligible**

Based on table 11 data from the assessment results of the Dinggo Sedaya website as digital teaching materials for early childhood education, approval was obtained from material experts at 98% and from media experts at 96%, these results are classified as "Very Appropriate". During the trial phase with a small group, a percentage of 89% was obtained with the classification "Very Eligible". Meanwhile, at the trial stage with a large group, a percentage of 87% was obtained with the classification "Very Adequate". Based on the overall data results, the Dinggo Sedaya website as a digital teaching material for early childhood education can be considered suitable for use as an effective, efficient, and attractive digital teaching material according to media experts, material experts, and users.

Discussion

This development research produces a website product that is presented as a digital learning resource for early childhood education. The Dinggo Sedaya website was created to meet the learning needs, especially for Early Childhood Education teachers through alternative digital learning resources that can develop learning and improve the digital literacy skills of Early Childhood Education teachers in utilizing technology. This research has been tested on Early Childhood Education Teachers Cluster 1, Kedungkandang Village, Malang City. Based on the data from the validity test results that have been carried out, the development of the Dinggo Sedaya website as a digital learning resource shows very good recognition from evaluations by experts, and the results of product trials with educators so that the Dinggo Sedaya website that has been developed can be said to be suitable for use as digital teaching materials for early childhood education. This is because the development of the Dinggo Sedaya website uses an appropriate and systematic development model, namely the ADDIE model which consists of several stages, namely the analysis, planning, development, implementation, and evaluation stages which make the work on the Dinggo Sedaya website structured so that it can minimize errors in the development process. In addition, the Dinggo Sedaya website is suitable for use as a digital learning resource for early childhood education due to several other factors such as effectiveness, efficiency, and the attractiveness of its products.

Judging from the aspect of effectiveness, the percentage results by two validators for the Dinggo Sedaya website are 98% and can be declared very feasible. Media experts stated that this website uses communicative sentences so that the information provided on this website can be captured by users. Communicative sentences can provide knowledge that can be understood by the communicator (Fadhila et al., 2022). The Dinggo Sedaya website has been tested in small groups, getting an average effectiveness aspect of 88% or it can be said to be very feasible. Based on the opinions of small-scale users, the effectiveness of this website is based on the website's content with the material needed by teachers in developing learning in early childhood education. This is related to the concept of learning resources that learning resources can be used as sources of information in various forms that provide facilities or ease of learning for students or teachers. The large group test in measuring the effectiveness of the Dinggo Sedaya website that was carried out received an average score of 86% or can be said to be very feasible. Teachers as users of this website stated that this digital learning resource has material coverage that is suitable for early childhood education, so that it can be used as reference material for teachers in developing learning. This is the opinion of Gitelman (2014) that the criteria for good learning resources are based on the suitability of the goals achieved based on instructional elements or child development elements. This is reinforced by Sudjana & Rivai that digital learning resources can make it easier for users to obtain media that is written easily and can be used as a supporting tool (Zyuro & Komalasari, 2020).

Judging from the efficiency aspect, the average attractiveness score by media experts is 96% and can be declared very feasible. Media experts say that this website can help teachers in designing learning through digital learning resources. This is Sudjana & Rivai's opinion that good learning

resources can give teachers skills to use in the learning process (Zyuro & Komalasari, 2020). This website needs to be optimized in terms of its completeness so that it can support users in operating the website by its development objectives. This is in line with the opinion of Wijaya et al., (2022) that in building a quality website the efforts that need to be made are completeness of content on the website, website design, speed, website domain extension, and website ranking in search engines. The Dinggo Sedaya website can also be operated anywhere and at any time by having a domain that is easy to remember so that it can make it easier for users to access it. Increasing the ease of accessing a website can be an effort to provide website visitors with comfort in accessing it (Khwaja et al., 2020). According to eight teachers in small group trials, the Dinggo Sedaya website is easy to access and can be used as a learning resource for early childhood children according to their developmental stage. This is by Sudjana & Rivai's opinion that good digital learning resources provide easy access and use as supporting tools and suit user needs (Zyuro & Komalasari, 2020).

Website as a digital learning resource for early childhood education is packaged according to good website systematics because it is tailored to consistency, completeness, convenience, and usability for target users. The users on this website are Early Childhood Education teachers so the completeness of the material adapts to the learning needs of early childhood. Learning needs for early childhood must be by developmental aspects that are oriented towards the child's development, needs, interests, and abilities (Hernawati, 2016). This opinion is reinforced by the opinion of Wiryotinoyo et al., (2020) that meeting learning needs can be supported through teachers' understanding and skills in utilizing varied media in learning practices. Based on this opinion, the development of the Dinggo Sedaya website has projects that can support learning which include materials, media, and learning methods that can be adapted to aspects of children's development. The results of large group trials obtained a percentage of 87% for the efficiency aspect. The teacher stated that the Dinggo Sedaya website has a presentation that is easy to access for teachers who are still in the learning stage of operating the website as a digital learning resource. Website-based digital learning resources can provide convenience and can be used anywhere and anytime flexibly (Sutriana & Ripai, 2022). This is reinforced by Suyanto's opinion that a good website is a website that provides ease of use (usability) and ease of access (accessibility) (Sa'ad, 2020). The Dinggo Sedaya website also has complete project content and news about Early Childhood Education Programs which can add sources of information for teachers in developing learning. By the results of research that has been carried out on the development of this website, the Dinggo Sedaya website can make it easy for users to access it and is complete as a complete source of information, especially in the scope of early childhood education.

Judging from the attractiveness aspect, the percentage results from material expert validation by two validators on the Dinggo Sedaya website show an average attractiveness value of 98% and can be declared very feasible. According to material experts, the Dinggo Sedaya website has a good website presentation that suits the needs of teachers in early childhood education. This is by the opinion of Setianto & Arifin (2016) that in website design it is necessary to focus on content that suits Early Childhood Education Programs needs. The language on this website is also good so the presentation is more communicative. The linguistic aspect of learning resources consists of sentence accuracy and writing accuracy (Setyadi & Qohar, 2017). Through the accuracy of sentences, complete information can be expressed as an effort to express thoughts completely (Rahayu & Yustiani, 2022). This is a benchmark that language presentation on a website needs to be communicative so that it can be understood by users. The development of digital learning resources for early childhood education should be carried out by the needs of learning resources that support learning for early childhood. The innovation provided to add digital learning resources for early childhood education is categorized according to aspects of early childhood development.

Media experts say that this website has an attractive website appearance to be used as a learning resource for early childhood education. Based on the opinion of Setyadi & Qohar (2017), the appearance of a website consists of the attractiveness of the images, suitability of the size of the images or writing, layout, and language displayed. Websites need to have an appearance with an attractive design and be well organized (Kurniawan et al., 2021). This makes the attractive appearance of the website able to provide user comfort in operating it. The Dinggo Sedaya website has been tested in small groups and it is concluded that the Dinggo Sedaya website is interesting to

use as a digital learning resource for early childhood education. It has been designed according to teachers' needs in developing learning because it is also supported by appropriate image or video visualization in each content. Images and videos can help users understand the context of the discussion. This is the opinion of Plab.id (2023) that by combining image, audio, and video elements in website design you can visualize the concept or product you want to convey. Based on large group trials, it received a positive response from teachers as users. The teacher stated that the Dinggo Sedaya website could help teachers develop learning tools that were packaged attractively and equipped with sentences and images as explanations of the existing content. Through the website, you can provide information services according to your needs in the form of images, video, audio, text, or other animations (Sutriana & Ripai, 2022). By the results of the research conducted, teachers find it helpful to develop this website as a digital learning resource to support learning. Based on the results of large group trials, it can be concluded that the Dinggo Sedaya website is stated to be very interesting, so this website can be said to be suitable for use as a digital learning resource for teachers in developing learning tools in early childhood education.

Benefit from studies These are results of products that can applied as digital teaching resources for education child preschool that can customized with needs, such as dimensions of growth child who can access For enrich experience Study. Therefore that's the result study This can used as a guide in the application of digital teaching resources in scope education child preschool. Additionally, research This own superior Because minimal studies about the development of special digital teaching resources For education child preschool so that can considered as one of the research that examines learning needs according to aspects of child development. However, this research also has limitations, namely that this website only contains material about early childhood education so that in the face of further research it can create media that can be utilized by higher levels of education. The findings obtained from this research produce research implications, namely that the Dinggo Sedaya website can be used as a variety of digital-based learning resources for early childhood education and can be used in learning tool development activities or to increase digital literacy competencies, especially for Early Childhood Education teachers.

CONCLUSION

This study shows that the development of the Dinggo Sedaya website is effective in supporting digital learning resources to help develop learning in early childhood education. The results of this study indicate that early childhood learning needs to be supported by media or platforms that can provide ease of use and are appropriate based on aspects of child development. This study confirms that the designed digital learning resources have great potential to support the achievement of interactive learning in early childhood according to current global challenges. This study has limitations in the scope of the research sample in only one cluster. Therefore, further research is needed that can accommodate a wider research scope to obtain a comprehensive picture. This study is expected to update the scientific perspective on early childhood education and be used as a basis for developing more appropriate media to support learning.

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Development of "*Tikrar* Space" multimedia based on drill and practice for Arabic vocabulary learning

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ABSTRACT

Multimedia drill and practice is a learning method that teaches skills through structured exercises to students by integrating various types of media, such as text, images, sound, and video. It can be applied in learning Arabic, especially to increase interest in learning and understanding or also called mufrodat on the subject matter of "اعضاء الجسم" (Members of the Body) Class V which is located at Global Islamic Elementary School. This study involved 20 students as the subject of this development research is to produce products and determine the validity of a multimedia drill and practice named "Tikrar Space". This research was conducted through the stages of analysis (needs analysis, task analysis, and learning analysis), design (objectives and assessments, learning strategies, and selection of delivery systems), development (material drafts, media production, and formative evaluation), implementation, and summative evaluation according to the Seels and Glasgow development model. The validation test results showed that the material expert validation resulted in a percentage of 95% and the media expert validation resulted in a percentage of 98%. Then, the results of student trials using multimedia amounted to 93%. Based on these results, it is concluded that this product is valid and can be used to interact in learning. Future research is suggested to integrate the latest technology with approaches such as gamification, adaptive learning, and collaborative learning, as well as the utilization of Augmented Reality and Virtual Reality to increase the effectiveness and interactivity of learning.

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INTRODUCTION

The modern era of education offers many changes, one of which is technology, which plays a crucial role in providing benefits and opportunities for students and educators. Technology has changed the learning environment to be interactive and adaptive, thus increasing knowledge and the ability to retain information (Rukmana et al., 2023). Technology has been widely integrated into various subjects, providing learning experiences that can be tailored to students' individual needs and preferences. Thus, technology is an option for improving learning outcomes and overall academic performance (Wekerle et al., 2022).

One of these subjects is Arabic. Arabic proficiency depends on vocabulary acquisition. If a person can master vocabulary, it reflects the level of language ability (Safitri, 2023). The purpose of

learning Arabic is so that students can pronounce vocabulary *(mufrodat)* according to the correct *makhraj* and then practice in the form of "جملة" or sentences (Hakim et al., 2019). The vocabulary acquisition process can be done in various ways which include social interaction, reading, listening, and repeated practice.

It needs to be addressed by applying appropriate methods to improve the quality of teacher and student interactions, empowerment of facilities, and learning components (Wijaksono, 2020). Repetitive exercises such as the drill and practice method can be an alternative in vocabulary acquisition, considering the cycles applied according to needs. The cycle includes an introduction section, select item, question and response, judge response, feedback, and closing (Alessi & Trollip, 2001). The concept of drill and practice is a learning approach that emphasizes repeated practice to strengthen understanding and skills regarding vocabulary in a language. In addition, drills and practice accommodate students in developing motor skills that are usually used in math, science, and language classes.

The results of observations and interviews with homeroom teacher V show that alternative learning media are needed to increase students' interest in learning, especially in understanding Arabic lessons on the material "أعضاء الجسم" (Body Members). This is because students are bored and easily understand less varied teaching methods. Although the school has facilities in the form of laptops and LCD projectors, their use is not optimal. Teachers realize that the current independent curriculum provides flexibility to choose various learning tools or open materials, but unfortunately, teachers still have difficulty integrating material into computer-based media. In addition, the use of book packages and teacher-centered approaches tends to be more dominant, which results in lower student satisfaction. Despite efforts to utilize learning platforms, students still have difficulty memorizing this is in line with the opinion of Wijaksono (2020) who states that Arabic has become a learning as well as a language icon at the Islamic-based school or madrasah level, but the results of its application are not optimal.

Research conducted by Jamroh & Nisa (2021) shows that inappropriate learning methods lead to a lack of student motivation and the perception that learning Arabic is difficult. This is due to the lack of teacher creativity in creating a fun and interesting learning experience for students. In this regard, the use of multimedia technology in learning can be an effective solution to overcome these obstacles. Multimedia makes learning more interesting and interactive and helps students apply Arabic in contexts relevant to everyday life, as shown in the research by Thoyib et al., (2024) regarding the integration of multimedia technology in Arabic language learning. Therefore, effective learning strategies and technology are needed to help learning activities become more effective and enjoyable.

According to other studies, the purpose of Arabic language learning is that students can pronounce vocabulary *(mufrodat)* according to the correct *makhraj* and then practice in the form of "جملة" or sentences (Hakim et al., 2019). From there, researchers unite the drill and practice method with Arabic language learning which, as to the statement of previous research, language learning is suitable for applying this method (Gunawan et al., 2020; Lestari et al., 2020; Mualimah et al., 2019). Likewise, in the development of multimedia drills and practice as a form of technology that presents multiple choice exercises, it is feasible to apply in foreign language learning. It facilitates individual interests (Sari et al., 2021). Thus, students are psychologically able to foster interest through appropriate methods. Using technology through interesting media can be a driving force to motivate students to learn foreign languages, especially those that are considered difficult.

The application of technology-based drills and practice in learning offers several significant advantages. The advantage is that it has the capability to help provide quick feedback regarding the correctness of the answers chosen by students. It not only encourages students to try to answer correctly but also strengthens the connection between stimulus and response. In addition, this method can optimize student engagement in the learning process, creating experiences that encourage active participation and deeper understanding (Kurniawan et al., 2019).

In the previous development, researchers found that multimedia was integrated with the drill and practice method through interactive quizzes, making it a learning medium for students (Mualimah et al., 2019). Multimedia is a computer technology application that can process, combine,

and display various types of files, including text, audio, video, images, and animation, with media and connections that allow users to interact and communicate with each other (Limbong & Simarmata, 2020). In the scope of learning, multimedia has a wide variety such as multimedia presentations, interactive, hypermedia, drill and practice, and tutorials. The drill and practice method is a learning technique that involves repeated practice and practice to improve skills and dexterity through material that has been learned (Nursehah & Rahmadini, 2021). Therefore, drill and practice-based multimedia is an interesting choice in combining the diversity of multimedia elements with learning methods that focus on repetitive practice, creating an interactive and effective learning environment.

In designing multimedia, it is necessary to pay attention to various principles. According to Mayer (2001), there are twelve multimedia principles based on cognitive science and information processing, which include coherence, signaling, redundancy, spatial continuity, time continuity, segmentation, pre-training, modality, multimedia, personalization, sound, and image. These principles have been applied in the development of learning media. For example, research by Gunawan et al., (2020) applied these principles to the development of multimedia drill and practice, which proved that the use of multimedia by paying attention to these principles can create media that is suitable for use to improve student understanding. In line with this, the researcher explores and develops multimedia drill and practice as a complex and effective media, including images, animations, and words that allow dynamic interaction between users and applications through navigation buttons.

In developing an interesting and appropriate learning multimedia, of course, an application is needed to create the multimedia, one of the applications chosen is PowerPoint. In general, PowerPoint is often considered a presentation tool with a one-way method, where educators present material to students. This means that students only become listeners and observers (Widyardi et al., 2023). However, by utilizing hyperlinks and animation features, PowerPoint-based multimedia interactivity can be adapted using the drill and practice method. This is accommodated through interactive slide design, interactive exercises or quizzes, animation as concept visualization, and instant feedback. All of this is presented by utilizing the hyperlink/action feature to move slides, and animation/trigger is used to operate multimedia by clicking on objects as triggers (Mona, 2021).

Previously, there was also research related to the needs analysis of elementary school students (Zain & Pratiwi, 2021), the results of the questionnaire analysis found that students strongly agreed and supported the creation and development of interactive PowerPoint-based learning media. PowerPoint can include audio, video, animation, and quizzes accompanied by feedback so that users can interact with the program. In addition, interactive PowerPoint is classified as an intermediate level, because it allows manual control using navigation buttons. This is to the characteristics of media classification based on the level of interactivity proposed (Schwier &Misanchuk, 1993).

Departing from the needs analysis and some previous research, learning media in the form of multimedia drills and practice is suitable to be developed using PowerPoint because it is more practical and easily accessible using laptop/computer devices. This is by the facilities provided at Global Islamic Elementary School. The main focus of this multimedia development is on the integration of several types of media, such as text, images, graphics, and animations that are designed according to the attractiveness and interactive standards for students. So that it can foster student participation, learning more fun, and assist teachers in the implementation of teaching.

Therefore, this research not only shows the validity of the material and media from the experts but also shows the results of student trials in using multimedia in Arabic lessons. The selection of the material "أعضاء الجسم" (Members of the Body) in the development of the media, because it is one of the basic materials in the lesson in class V which provides a practical dimension to Arabic language learning. So that by using the drill and practice method in multimedia, students can directly associate the vocabulary with concrete objects that are realized in the form of visualization in the form of images and hone memory through repeated practice. This makes it easier for students to internalize vocabulary more effectively.

METHOD

This research and development procedure uses the Seels & Glasgow (1998) model. This development model extends the five basic steps of the ADDIE model with an Instructional Systems Design (ISD) model aimed at beginners (Seels & Glasgow, 1998). When compared to other models, this model emphasizes students' needs and preferences in the learning process and provides a strong framework for outlining the process through more specific steps (can be seen in Figure 1).

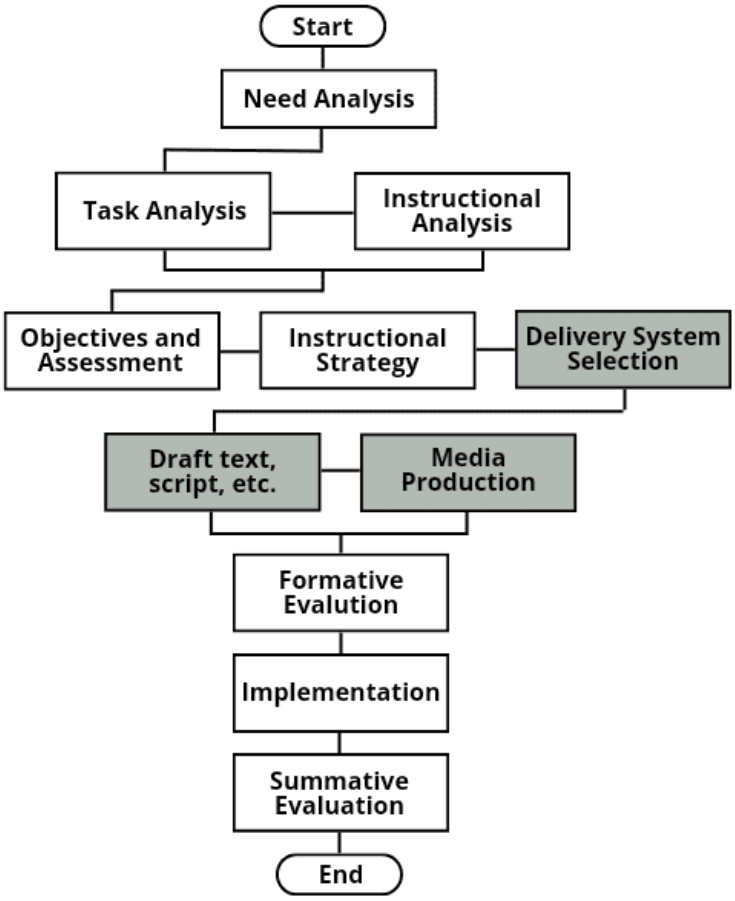

Figure 1. Seels & Glasgow's ISD Model

Figure 1 Seels and Glasgow start the analysis stage including needs analysis, task analysis, and instructional analysis. Needs analysis is used to determine the existing needs of the institution so that the solution produced later can meet the objectives. Task analysis involves identifying tasks and activities by reviewing indicators and learning objectives. Instructional analysis includes identifying the learning materials that must be delivered as well as the most effective methods to deliver those materials. The design stage should include learning and assessment objectives (developing assessment instruments), instructional strategies, and selection of delivery systems. The development stage includes draft materials, media production, and formative evaluation. The implementation stage involves testing the materials and media. Summative evaluation aims to help schools/teachers assess the overall impact of the media over a long period. However, in this study, summative evaluation was not conducted because the implementation was not used as a whole, but only a small-scale trial.

In this study, several types of questionnaires were used, namely expert validation questionnaires, material experts, and student response questionnaires. The validation questionnaire is used by researchers to collect data related to the validation of products that have been made. This questionnaire will be filled in by material experts and media experts. The use of validation questionnaires has the main objective of obtaining assessments, criticisms, or suggestions from experts regarding the products that have been developed by researchers. Furthermore, individual

trials were carried out by 5 people, a large group consisting of 10 students, and a small group consisting of 5 students. The instrument used is a closed questionnaire containing 10 items for material experts, 12 items for media experts, and 20 items for students as users. The questionnaire provided a column to provide comments in the form of suggestions on the multimedia developed by researchers. So, the data is generated in the form of quantitative and qualitative data.

Quantitative data was obtained from the assessment on the validation sheet and student response questionnaire using a Likert scale consisting of 4 answers, namely, SA (Strongly Agree), A (Agree), D (Disagree), and SD (Strongly Disagree) (Sugiyono, 2019). Furthermore, the data is processed to obtain the results of the level of validity of the multimedia drill and practice developed using the percentage formula in the form of dividing the number of assessment scores by the maximum number of scores, then multiplying by one hundred percent. The level of validity is known from the interpretation of the score in the form of numbers into a category. Meanwhile, qualitative data is obtained from comments in the form of criticism or suggestions given through validators.

Table 1. Level of Validity

No.	Category	Score Range (%)
1	Very Good	81% - 100%
2	Good	61% - 80%
3	Sufficient	41% - 60%
4	Less	21% - 40%
5	Very Less	0% - 20%

(Akbar, 2013)

In the media expert validation questionnaire, the aspects assessed are aspects of navigation or media operation, display aspects, media audio aspects, and benefit aspects. The material expert validation questionnaire consists of aspects of content feasibility, language aspects, and presentation aspects. The student response questionnaire includes aspects of appearance or presentation, aspects of operation, and aspects of user interaction and reaction. These activities are used to determine student responses to multimedia. Data analysis techniques contain how to interpret the data obtained and its relation to the problems and research objectives. For experimental research, it is not necessary to write down statistical formulas, but it is sufficient to state which test was used and the decision-making criteria. For qualitative research, researchers also need to describe the things that are done to ensure the validity and consistency of research results.

RESULTS AND DISCUSSION

Results

The results of this development are in the form of a multimedia drill and practice "*Tikrar* Space" which contains the material "Members of the Body" with the research subject being 20 fifth-grade students at Global Islamic Elementary School in Arabic language subjects. In its creation, the Canva application is used to produce a display design that contains elements such as images, icons, and backgrounds. After designing in Canva, the results were then downloaded in the form of PowerPoint format. PowerPoint is used so that the design elements that have been made before become interactive multimedia by utilizing hyperlink/action and animation/trigger features. Through these features, the resulting multimedia can be explored using navigation buttons and enriched with animation and audio.

The strategy developed in this multimedia is the use of interactive quizzes to practice vocabulary comprehension. Multimedia elements that include images and audio are applied to enrich the material and assist students in linking vocabulary with a more real context. The setting of difficulty level of the questions is adjusted to the level of material in the Arabic subject, namely *mufrodat* and *tarkib*, both of which contain ten questions each that will provide immediate feedback. The types of questions given are only wrong/right and are supported by moving images and animations. In addition, this multimedia has various features or menus such as sound, music, home, instructions, profile, information, and goals.

Figure 2. Home and Menu Display

Based on Figure 2, a home display with various buttons is presented, such as music, sound, instructions, profile, information, goals, and navigation buttons (back and close), as well as the title of the material to be studied. The button is used to make it easier for students to explore this multimedia. In addition, there are moving animations accompanied by musical accompaniment to increase students' interest in learning. In the menu display, there are categories of material (in the form of buttons) according to their level, namely *mufrodat* and *tarkib*. The purpose of presenting categories is so that students can choose exercises according to their level of difficulty.

Figure 3. Quiz

Based on Figure 3, the drill and practice method is applied through exercises/quizzes, where body members or movements are visualized using animations. Each slide is accompanied by several buttons. In addition, music with a play/pause button accompanies each exercise. Likewise, audio buttons make it easier for students to understand how to read Arabic vocabulary according to the rules. The drill and practice cycle in this media is that if students can answer the question correctly, they can move on to the next exercise, which is marked by feedback in the form of sound and animation "wrong" or "correct".

The product was developed and tested on experts and students using a Likert scale questionnaire consisting of 4 answers, namely, 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree) (Paramita et al., 2022). Furthermore, for the validity quality criteria according to Akbar (2013), if the value is in the percentage range of 81% - 100% then it is included in the criteria very valid or feasible to use. The following is a diagram and table presentation of the results of validation data processing and trials for media experts, material experts, and students as research subjects.

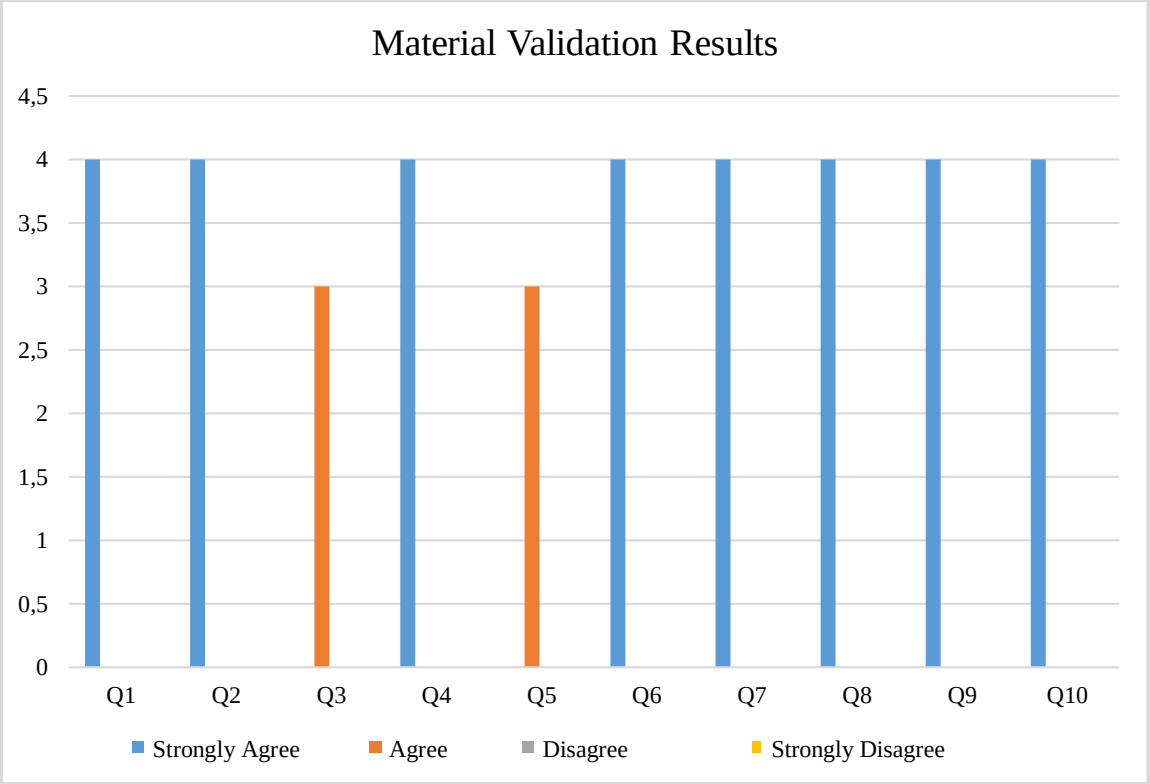

Figure 4. Diagram of Material Expert Validation Results

Figure 4 shows that the diagram of the material expert validation results using a scale of four on multimedia drill and practice, there are 8 out of 10 items that get a strongly agree scale, indicating a high level of approval from the material expert on various aspects (see Table 2). In addition, 2 items on the agreed scale, signaled positive acceptance but with a slightly lower level of agreement. These results reflect the success of multimedia in meeting the material standards and criteria and provide a positive picture of the quality and feasibility of the drill and practice multimedia product. The statements on the material expert validation instrument were adopted from the research of (Fajriah, 2015; Rofidah et al., 2020) with an expert providing the answers (see Table 2).

Table 2. Presentation of Data on Material Expert Validation Results

No.	Code	Indicator	X	X1	Percentage
A. Content Feasibility					
1.	Q1	The Suitability of the Material with the Basic Competencies, Indicators, and learning Objectives that Students must master	4	4	100%
2.	Q2	The Accuracy of the Material is in Accordance with the Level of Student Development	4	4	100%
3.	Q3	The Accuracy of the Concepts Presented is Easy for Students to Understand	3	4	75%
4.	Q4	The Accuracy of the Images is Easy for Students to Understand	4	4	100%
5.	Q5	Clarity of Instructions for Use	3	4	75%
B. Language					
6.	Q6	The Language used is the Rules of Indonesian and Arabic Writing	4	4	100%
7.	Q7	The Language used is Appropriate for the Students' Level of Thinking	4	4	100%
C. Presentation					
8.	Q8	The Material Presented is in Accordance with the Teaching Material	4	4	100%
9.	Q9	Suitability of Questions and Answers	4	4	100%

No.	Code	Indicator	X	X1	Percentage
10.	Q10	Appropriate Picture Presentation in Accordance with the Vocabulary	4	4	100%
Total			**38**	**40**	**95%**

The results of the material expert assessment (see Table 2) for quantitative data, canbe analyzed that out of 10 items, there are 8 items that have a percentage of 100% and 2 items with a percentage of 75%. Then, if totaled, the result is 95%. Based on the criteria set, it can be concluded that multimedia drills and practice Arabic language subjects meet the valid criteria and are suitable for use as learning media.

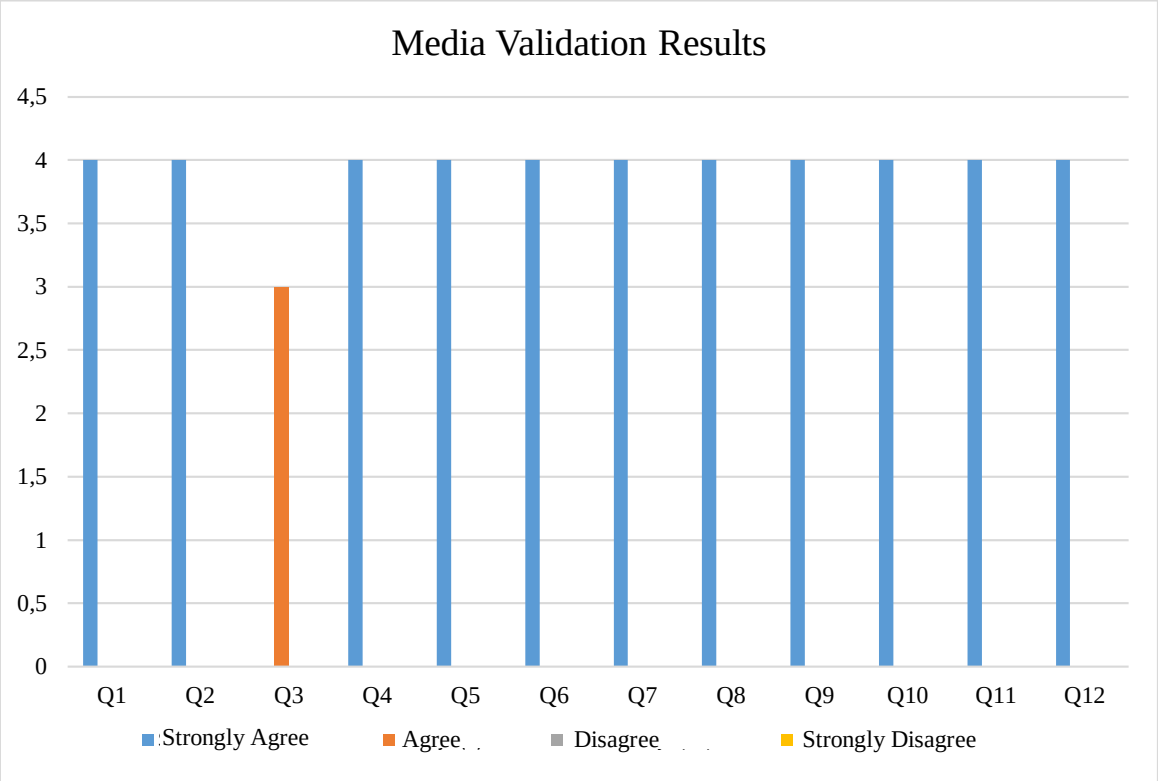

Figure 5. Diagram of Media Expert Validation Results

Figure 5 shows that the diagram of the media expert validation results, from a total of 12 items assessed, 11 items received a scale of "strongly agree," and 1 item obtained a scale of "agree". These results reflect the media expert's positive acceptance of the various aspects assessed in the multimedia. The high consistency of the assessment indicates that the material contained in the drill and practice multimedia is considered valid so it is suitable for use in learning Arabic. The material expert validation instrument (see Table 3) was adopted from the research of (Dwiqi et al., 2020; Zahra et al., 2021) with an expert providing the answers.

Table 3. Media Validation Instrument

No.	Code	Indicator	X	X1	Percentage
A. Navigation / Media Operation Aspect					
1.	Q1	Ease of Operation of Learning Media	4	4	100%
2.	Q2	Instructions for use Presented are Complete	4	4	100%
B. View					
3.	Q3	Accuracy of Button Placement	3	4	75%
4.	Q4	Attractiveness of Colors, Backgrounds, Images, and Audio	4	4	100%
5.	Q5	Readability of Text	4	4	100%
6.	Q6	Appropriateness of Background Color with Text Color	4	4	100%
7.	Q7	The Overall Program Provides a Pleasant Learning Atmosphere	4	4	100%

8.	Q8	Color Combination and Composition	4	4	100%
C. Presentation					
9.	Q9	Voice Clarity	4	4	100%
10.	Q10	Suitability of Voice with Material	4	4	100%
D. Benefits					
11.	Q11	The Overall Program Provides a Pleasant Learning Atmosphere	4	4	100%
12.	Q12	Clarify and Simplify Message Delivery	4	4	100%
Total			**47**	**48**	**98%**

From the results of the media expert assessment (see Table 3) for quantitative data, it can be analyzed that of the 12 items 11 items have a percentage of 100% and 1 item with a percentage of 75%. Then, the total of all indicators reaches 98% which indicates the quality of this media meets the standards. Based on the criteria set, it can be concluded that the drill and practice multimedia for Arabic language subjects meets the valid criteria and is suitable for use as learning media.

Student response is the student's response to the use of multimedia through filling out an attractiveness questionnaire. The pilot test was conducted with the same questionnaire indicators in various groups (large groups, individual groups, and small groups). Results from large groups can help understand how the product is received by many audiences; results from individual groups can help understand how individual responses to the use of the product; and results from small groups can help understand how social interaction affects the acceptance of the product as a learning medium. This can create more comprehensive results and provide a stronger basis for further development efforts or improvements to the already developed product. The following table presents the indicators of the attractiveness instrument as a form of student response (see Table 4), containing 20 items adopted from research (Dwiqi et al., 2020; Kartini & Putra, 2020; Zahra et al., 2021).

Table 4. Indicators of Attractiveness Instrument

No.	Code	Indicator
A. View		
1	Q1	I think the Content Content of this Multimedia is the Learning Material.
2	Q2	I like the Colors and Fonts used in this Multimedia because they are Attractive.
3	Q3	I think the Images, Backgrounds, and Animations in this Multimedia are Interesting.
4	Q4	I think the Audio/Sound Contained in this Multimedia Sounds Good
5	Q5	The Music in this Multimedia Makes me Feel More
6	Q6	I can Read and Understand the Text Clearly
7	Q7	I Enjoy Learning using this Multimedia.
8	Q8	I can Easily Understand the Language used in this Multimedia
B. Operation		
9	Q9	I can Easily Operate/use this Multimedia
10	Q10	Multimedia Design Makes me more Interested in Learning
11	Q11	The Instructions for using the Multimedia are Easy for me to Understand
12	Q12	I can Easily Navigate/Explore the Content of this Multimedia.
13	Q13	The Clarity of the Menu Helps me Focus on the Material I Want to Learn.
C. User Interaction and Reaction		
14	Q14	I Feel More Active in Learning by using this Multimedia
15	Q15	I don't Feel Bored or Saturated while using this Multimedia.
16	Q16	I feel that this Multimedia can Help me Understand the Material Better.
17	Q17	I Feel More Excited to Learn Through Multimedia.
18	Q18	I can Easily Memorize and Understand Learning Materials using this Multimedia.
19	Q19	I was Able to Concentrate while using this Multimedia
20	Q20	I think the Answers and Questions Contained in the Multimedia are Appropriate.

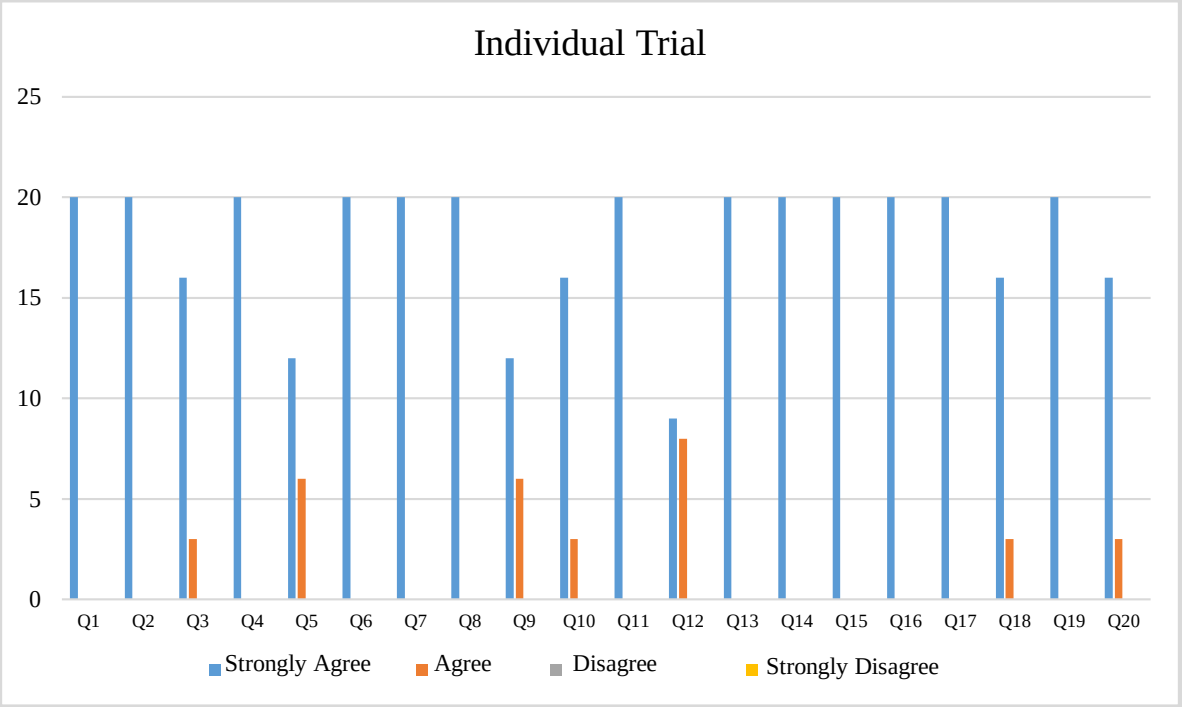

Figure 6. Diagram Individual of Trial Results

The results of the individual trial with the participation of 5 people and a four-point rating scale obtained a score of 97%. This is evidenced by Figure 6, which shows that in the diagram of the individual trial results, respondents gave more "strongly agree" ratings than "agree" ratings alone. This proves that the drill and practice multimedia "*Tikrar* Space" successfully attracts the interest of each individual and signifies its positive potential in supporting Arabic language learning.

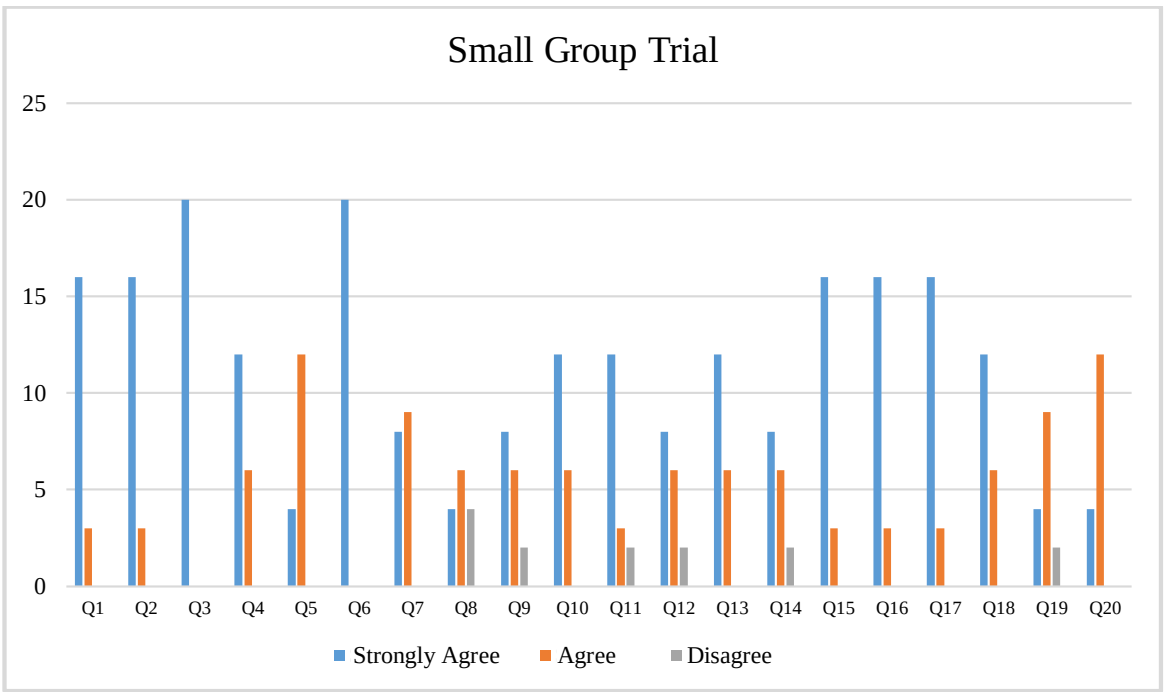

Figure 7. Diagram of Small Group Trial Results

The results of the small group trial obtained a percentage of 88%, it was based on responses from 5 respondents. Figure 7 shows that in the diagram of the trial results, respondents "strongly

agree" or "agree" get a significant number which shows a good level of acceptance of the multimedia. Although some statements get a "disagree" assessment, the number is relatively small. This proves that the drill and practice multimedia "*Tikrar* Space" is valid, with the results of trials conducted together or in groups.

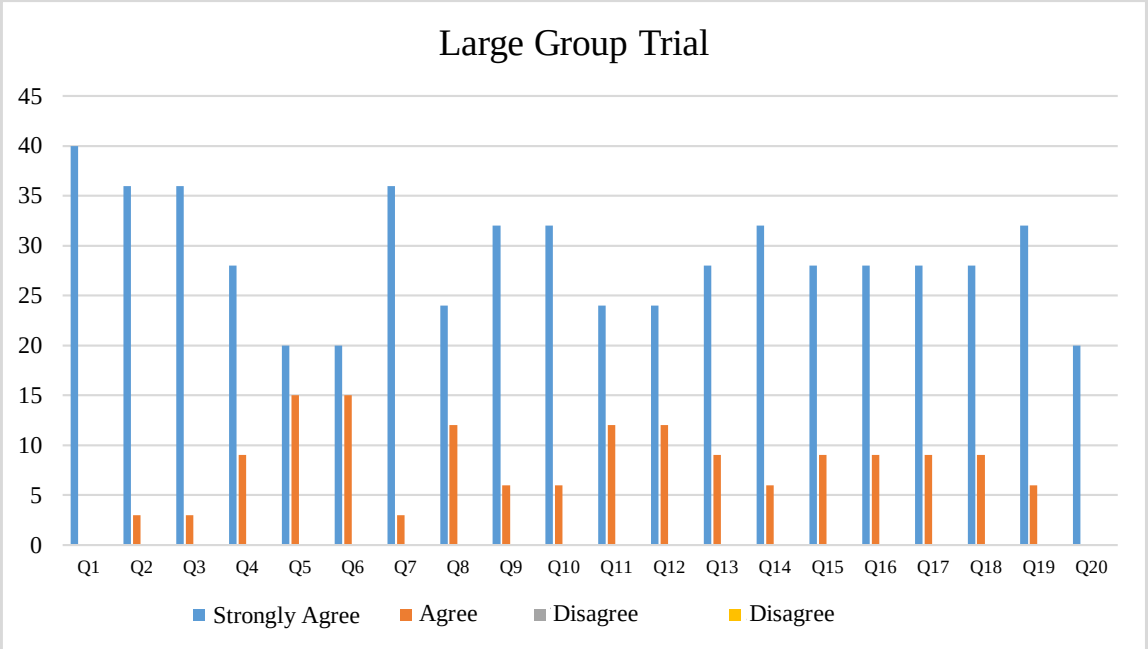

Figure 8. Diagram of Large Group Trial Results

The actions taken in the large group trial were almost the same as in the small group trial, except that the number of students in one large group consisted of 10 students. The results of the large group trial obtained a percentage of 94%, as evidenced by Figure 8 which shows that in the diagram of the results of the large group trial, all respondents gave positive values, namely "strongly agree" and "agree" only. This shows that multimedia drills and practice are generally well received, and the results of this trial provide a positive picture of product acceptance by students in using media for Arabic language materials.

Table 5. Descriptive Statistic Data

No.	Item	N	Minimum	Maximum	Mean	Std. Deviation
1	Q1	20	3	4	3.95	0.224
2	Q2	20	3	4	3.9	0.308
3	Q3	20	3	4	3.9	0.308
4	Q4	20	3	4	3.75	0.444
5	Q5	20	3	4	3.45	0.510
6	Q6	20	3	4	3.75	0.444
7	Q7	20	3	4	3.8	0.410
8	Q8	20	2	4	3.5	0.688
9	Q9	20	2	4	3.6	0.598
10	Q10	20	3	4	3.75	0.444
11	Q11	20	2	4	3.65	0.587
12	Q12	20	2	4	3.45	0.605
13	Q13	20	3	4	3.75	0.444
14	Q14	20	2	4	3.7	0.571
15	Q15	20	3	4	3.8	0.410
16	Q16	20	3	4	3.8	0.410
17	Q17	20	3	4	3.8	0.410
18	Q18	20	3	4	3.7	0,470
19	Q19	20	2	4	3.65	0.587
20	Q20	20	3	4	3.75	0.444

The tabulated data on student responses to the use of multimedia drill and practice (see Table 5) show a generally positive response, with mean values ranging from 3.45 to 3.95 on a scale of 1-4. Most of the items show stability in student responses, reflected in the relatively low standard deviation value, which indicates that student responses to each item tend to be homogeneously or uniformly distributed. Nonetheless, some items showed higher variances and somewhat lower means, indicating differences in students' opinions or interpretations. Overall, however, these findings provide a positive picture of student acceptance of multimedia drills and practice.

So, the results of the trial of 20 students through individual trials with 5 students, small groups with 5 students, and large groups of 10 students obtained a recapitulation value of 93%. According to the results of the data processing above, it can be concluded that the drill and practice multimedia product in Arabic language lessons is declared valid.

Discussion

The drill and practice method applied in the multimedia developed by researchers is based on behavioristic theory, constructivist theory, and cybernetic psychology theory. Behavioristic theory emphasizes behavior change through habituation or repeated practice and reinforcement of responses, either through the use of rewards or punishments (Shahbana et al., 2020). The constructivist theory emphasizes providing opportunities for students to practice and practice independently to construct language skills with previous abilities. In addition, cybernetics theory highlights the importance of feedback as a means of behavior control and modification (Padlurrahman, 2019). Drill and practice with the application of this theory is proven to be able to improve student skills (Herliana et al., 2019). Meanwhile, the cognitive domain of using the drill and practice method in this study can improve vocabulary mastery by strengthening students' memory (remembering) and understanding (understanding), according to levels C1 and C2 in Bloom's Taxonomy (Fauzet, 2016). The application of the cognitive domain of the remembering level in the activity of memorizing *mufrodat*, then the understanding level in the context of using vocabulary in the form of sentence patterns or called *tarkib*.

Learning multimedia development products using the drill and practice method for Arabic language subjects for grade V students. It was developed to know the feasibility and validity of multimedia drills and practice as an alternative learning media in increasing interest in learning Arabic and enriching vocabulary mastery (*mufrodat*). The multimedia design is adapted to the characteristics of elementary school students who tend to like animations or cartoons like astronauts. This is also the basis for giving the name to this multimedia, namely Tikrar Space. Previous research also developed drills and practice multimedia to help students expand vocabulary in learning Japanese for high school students (Lestari et al., 2020). Departing from that research, researchers sought to develop media for elementary school students tailored to the attractiveness and interest of students in learning Arabic.

The innovation in multimedia development by researchers lies in the integration of visuals, audio, and interesting animations, emphasizing the interactivity aspect. The design of the multimedia interface utilizes the Canva application. In designing, the principles of Mayer (2001) are applied, although not all principles are implemented. To ensure that each element is interconnected and forms a clear and understandable message, the principle of coherence is applied when using the elements of limb images and text as answer choices. Redundancy is applied through the use of menu icons without text and pictorial questions to reduce unnecessary information. Signaling is reflected in the emphasis of words through different shapes and colors, as well as the presentation of several slides to separate each learning topic. By Mayer's principle, the use of graphic elements such as images, icons, and shapes is emphasized in the interface design to increase visual appeal and support the delivery of messages more clearly. The application of Mayer's principle in developing interactive multimedia design as learning media provides significant results (Sinaga et al., 2023). Therefore, developing interfaces by taking into account Mayer's principles is a strategic step to create quality multimedia that supports learning objectives.

In this study, these principles support the increase of students' interest and reduction of cognitive load towards learning Arabic. This research is in line with the findings of Putri & Muhtadi

(2018) which also shows that the use of Mayer's principles in multimedia can increase learning effectiveness. Likewise, in the development carried out by researchers, namely the use of time continuity through "right/wrong" animations along with audio, thus successfully creating a more interesting learning experience. Personalization, by integrating communicative audio, can meet the needs of students. Therefore, the results of trials and validation that have been carried out by researchers show the effectiveness of these principles by the data described above.

The interface design in Canva was then turned into an interactive one using the hyperlink/action and animation/trigger features in PowerPoint. This process involved emphasizing interactive elements, including navigation buttons, practice questions, and several other responsive elements. The presentation of interactive material helps students to see concretely, which was previously abstract (Havizul, 2020). In addition, the material is adjusted to the learning indicators, and equipped with instructions for using the media. When indicators, basic competencies, learning objectives, learning materials, and evaluations are by the learning objectives of the teaching materials, they can support the learning process such as making it easier for students to understand the material (Dwiqi et al., 2020). This is in line with this research which produces multimedia with various features that make students more enthusiastic about participating in learning activities.

Multimedia includes various features and exercises that can be done repeatedly as an indicator of the application of the drill and practice method. Drill and practice-based learning media provide instant feedback to provide information about student performance through correct or incorrect detection (Purba et al., 2021). The focus on these exercises helps students to focus more on the material that must be mastered. Based on the material expert's response to the "*Tikrar* Space" multimedia drill and practice product, the aspects of content, language, and presentation feasibility are positively assessed. The learning materials included are the learning objectives of Arabic adapted from the student handbook. In addition, the material expert also gave suggestions that the Arabic writing on each illustration/image used could be read clearly, and used a familiar font, such as *Traditional Arabic*, *Sakkal Majalla*, or *Droid Kufi Arabic*. But overall, the material expert assessed that the material in this media already has good quality.

The results of the review from the media expert, the navigation/operation aspects of the multimedia drill and practice product are also considered positive, which has reached a good standard. These results are supported by research that states that the review of multimedia drills and practices obtained from media experts and material experts shows a positive value (Lestari et al., 2020). In particular, media experts appreciate the appearance of multimedia because it is attractive and by Mayer's principles. Even so, it would be nice if the button format used could be optimized. The audio aspect also received a good assessment with the use of the researcher's voice that supports learning. Not only that, the benefit aspect of this multimedia is considered to be able to help students understand and master Arabic vocabulary.

Based on the results of student trials through a series of product trials of multimedia drill and practice "*Tikrar* Space", this product is considered to have attractive qualifications. The level of attractiveness of this multimedia is obtained from individual trials, small-group trials, and large-group trials. In terms of appearance and presentation, this multimedia gives an attractive and easy-to-understand impression, thus providing an effective attraction for students. Students' responses to the operation of this multimedia prove that it is easy for students to explore the content and have an enjoyable experience. Interactive features in the multimedia provide opportunities for students to actively participate in learning activities (Nuritno et al., 2017). Overall, students' reactions show that the drill and practice multimedia "*Tikrar* Space" suits students' needs and preferences. Thus, a good response from students is an indicator of success in developing multimedia for Arabic language learning.

CONCLUSION

Learning Arabic for some students is not considered easy, making it a boring learning situation. So, students need a product that can support the learning process of Arabic, especially in mastering *mufrodat* (vocabulary). The development of multimedia drills and practice "*Tikrar* Space" is an alternative step in overcoming these problems. Based on the results of the study, the material

validity test results were obtained at 95%, and the media validity test obtained a value of 98%. Meanwhile, the recapitulation of the results of the trial to students obtained a score of 93%. This research proves that the use of multimedia by applying the drill and practice method in Arabic lessons gets a good response from students as users. The use of this multimedia obtained positive reviews from media experts, material experts, and students as research subjects, where the multimedia is valid to show its potential as an interesting learning media and worth using. Suggestions, for further research can integrate technology in learning and combine it with various approaches such as gamification, adaptive learning, collaborative learning, as well as the use of Augmented Reality and Virtual Reality to increase the effectiveness and interactivity of learning.

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