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Development of A Mobile-App-Based E-Assessment Oriented Towards Science Literacy For Prospective Science Teachers

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Abstract — This study aims to develop and test a mobile-app-based e-assessment oriented towards science literacy for prospective science teachers. The research and development (R&D) method with the 4D model was employed in this study. A multiple-choice test instrument with reasoning was developed to measure the science literacy skills of prospective science teachers. The instrument was validated by material experts and media experts to ensure its validity and reliability. The results showed that the developed mobile-app-based e-assessment is valid, reliable, and practical to use. Limited trials indicated that the application is effective in improving the science literacy of prospective science teachers. This research contributes to the development of innovative and effective technology-based assessment instruments to improve the quality of science education.

Keywords: e-Assessment; Mobile-app; Science Literacy; Prospective Science Teachers.

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1. Introduction

In the digital era of the 21st century, technology has become a major driver of transformation in various sectors, including education. In the context of education, assessment, as a benchmark for learning success [1], is also required to adapt to this technological development. The need for innovative, efficient, and technology-integrated assessment methods is increasingly urgent.

Assessment in education is not merely about measuring student learning outcomes but also involves gathering in-depth information about the process, products, and attitudes of students towards learning. This information serves as a basis for educators to make important decisions regarding learning. However, traditional assessment methods often face challenges, such as limitations in measuring higher-order skills, lack of objectivity, and time-consuming processes [2].

The presence of technology offers potential solutions to overcome these challenges. One promising innovation is e-assessment or electronic-based assessment. E-assessment utilizes computers and the internet to create a more flexible, efficient, and engaging assessment process [3]. The advantages of e-assessment include ease of access, time and resource savings, and the ability to minimize cheating and subjectivity [4].

The development of mobile devices such as smartphones and tablets has driven the utilization of technology in learning. Mobile-app-based e-assessment offers greater flexibility and ease of access for students and teachers [5]. Students can learn and take assessments anytime and anywhere through interactive and engaging mobile applications [6,7].

Science literacy, as one of the key 21st-century skills, has become an important focus in education today [8]. The ability to understand and apply scientific concepts critically is essential in facing increasingly complex global challenges. Mobile-app-based e-assessment can be an effective tool in measuring and improving students' science literacy.

This research focuses on the development of a mobile-app-based e-assessment specifically designed for prospective science teachers. By integrating mobile technology into the science literacy assessment process, it is expected to provide innovative solutions to overcome the limitations of traditional assessment and improve the quality of science education in Indonesia.

This research employs the 4D model, consisting of the define, design, develop, and disseminate stages. The define stage involves needs analysis, literature review, and initial observations. The design stage includes question planning, test format selection, and the formulation of science literacy indicators. The development stage encompasses the creation of a question bank, initial media interface design, and expert validation. The disseminate stage involves limited trials and extensive trials to evaluate the effectiveness and practicality of the developed e-assessment.

The utilization of mobile technology in assessment has a positive impact on learning. Mobile assessment integrated with mobile learning not only provides ease of access but also increases students' motivation and readiness to face tests [9]. Research findings indicate that system quality is a major factor in driving the acceptance and use of mobile assessment among students [10].

Mobile-app-based e-assessment offers various benefits, ranging from cost reduction to increased objectivity in assessment [11]. Moreover, the use of this technology can also prepare prospective teachers to effectively integrate technology into their future teaching practices [12]. This research is expected to make a significant contribution to developing an innovative assessment model that is relevant to the needs of 21st-century education. By harnessing the potential of mobile technology, e-assessment can become an effective tool in improving the quality of education, particularly in the field of science.

2. Methodology

This research employs the research and development (R&D) method with the 4D model [13], which consists of four stages: (1) Define: This stage involves analyzing the needs of prospective science teachers in terms of science literacy and the use of technology in assessment, as well as reviewing literature related to e-assessment and science literacy; (2) Design: This stage focuses on designing the mobile-app-based e-assessment application, including the program structure, user interface, and question content that aligns with science literacy indicators. Flowcharts and storyboards are used as guides in the application development process; (3) Develop: In this stage, the mobile-app-based e-assessment application is developed using Flutter software. Science literacy questions are incorporated into the application. Subsequently, the application is validated by material experts and media experts to ensure its quality and feasibility. After validation, the application undergoes limited trials with a group of prospective science teacher students. Feedback from these trials is used to refine and improve the application; Disseminate: This stage involves extensive trials of the application with prospective science teacher students from various universities. Additionally, Focus Group Discussions (FGDs) are conducted to gather further input from users. The research and development product results will also be disseminated through seminars or conferences, as well as scientific publications.

This research involves Master of Science Education students as research subjects. Purposive sampling technique is used to select the sample, with the criteria that all subjects are prospective science teachers currently pursuing Master's studies.

3. Results and Discussion

The product development process involved creating and refining the necessary media elements for the mobile-app-based e-assessment, adhering to the detailed content plan. During the development stage, the created product underwent validation by experts. The developed content was then meticulously reviewed and revised to address any potential errors. Additionally, a limited trial was conducted in a classroom setting at a university, with prospective teachers as the test subjects. The trial results served as the basis for further improvements to the product. The detailed outcomes of the development stage are outlined below.

3.1. Test Instrument

The developed test instrument was designed to measure science literacy skills. The written test consisted of multiple-choice questions with reasoning components. Each science aspect was assessed with 30 questions. The instrument also included a scoring rubric to facilitate the evaluation process. The developed questions were then subjected to accuracy testing through content validity assessment. Content validity was established by material experts to assess the instrument's accuracy in measuring the science literacy of prospective science teachers. The results of the science literacy test instrument validation are as follows.

Table 1. Results of the Science Literacy Test Instrument Assessment

No	Aspect	Assessment Score	Category
1	Material	4,58	Very Good
2	Construction	4,83	Very Good
3	Language	4,16	Very Good
	Average	4,53	Very Good
	Aiken’s V	0,91	Very Good

Based on the assessment results, the Aiken's V value for the test instrument's validity was 0.91. This result falls into the "very good" category, indicating that the test instrument is suitable for use as a means of evaluating science literacy learning. The test instrument, having met the feasibility criteria, can then be integrated into the program for further development into a mobile product.

3.2. Mobile-app

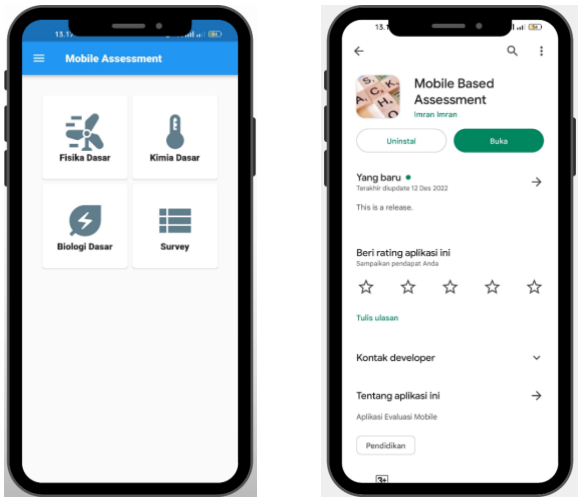
Mobile App The mobile app was developed based on the targeted science literacy achievements. The app is equipped with several elements of product development, including a homepage, main menu, developer profile, user instructions, and the e-assessment instrument. The app development was aided by several supporting software, including Google Forms.

The mobile app was created as a webview application using Flutter. Flutter is a platform widely used in multi-platform app development. Among the advantages of using Flutter is its extensive community. The large community of a platform is highly beneficial, as it typically results in high support in the form of plugins, documentation, and tutorials within the platform. Flutter also utilizes a single codebase system. Consequently, the application only needs to be developed once and can be used across various platforms, such as Android, iOS, web, and desktop.

The initial step after selecting the development software involved inputting the questions into Google Forms. Several factors need to be considered when adding questions to Google Forms. Developers must choose the appropriate question types and pay attention to mobile usability. After the questions are finalized, the process continues with the creation of the user interface.

In the user interface creation stage, the chosen design was material design, which is popularly used in modern mobile applications today. The main menu or homepage contains several buttons that function to direct users to the Google Forms links created in the previous stage. To enable the buttons to make requests to the Google server to display the forms, the http package provided by Flutter was utilized. This package functions to download data from a link into the application, which is then displayed.

The data downloaded from the server is still in raw format and cannot be directly displayed by the application. To enable display, another package called webview was used. The display within the application was also adjusted to fit the mobile screen size. The next process involved making all questions displayed in the application controllable through a sheet in Google Sheets. The list of questions that can be worked on is listed there, and those will be displayed in the application. Questions removed from Google Sheets will also be removed from the application. Scores can be automatically displayed in the application, not just sent automatically via email. The development results were then compiled into an .apk format (Android application) for subsequent evaluation by media experts. The results regarding product development can be seen in the following Figure 1.



(a) (b)

Fig. 1. Display of the Developed Mobile-App-Based E-assessment Product
(a) Main menu of the application, (b) Application successfully registered on the Play Store.

The questions, initially inputted into Google Forms, were then linked through the creation of a user interface. This process involved integration with the help of several software packages, such as the http package by Flutter and webview. The aim was to transform these questions into a mobile-based format (e-assessment via mobile app). Once the product was ready in the form of a mobile app, its feasibility was tested.

The validation stage is part of the testing process to assess the product's feasibility. This validation was conducted by experts in media (technology) learning, with an evaluation of the mobile e-assessment application. Validity testing is necessary to ensure confidence in the device's suitability for use.

The results of the feasibility assessment for the mobile app-based e-assessment indicate that the product falls into the "very good" category and is suitable for use (Table 2). This outcome is further supported by the validator's decision, along with the limited number of suggestions and feedback received. The product's appearance (design) gives a fairly attractive and interactive impression.

Moreover, the validator's assessment shows a very high score in the aspect of software engineering. As with any mobile product development, software engineering must be prioritized as it is a key factor in achieving the application's development goals. If the application feels cumbersome, users will not use or install it. The most crucial aspect in utilizing technology, including mobile apps, is performance.

Table 2. Assessment Results of Mobile-App-Based E-assessment Media

No	Aspect	Score	Category
1	Display (Design)	3,96	Good
2	Software Engineering	4,93	Very Good
	Average	4,44	Very Good
	Aiken's V	0,89	Very Good

The product, which has been developed and declared feasible, was then tested to assess its practicality and effectiveness. The trial was conducted with several prospective science teacher students. The detailed results of the trial can be seen in Tables 3 and 4 below.

Table 3. Results of Product Practicality Assessment in Initial Trials

No	Aspect	Score	Category
1	Ease of use	4,34	Very Good
2	Usefulness	4,22	Very Good
3	Interest in the product	4,17	Very Good
4	Enthusiasm for use	4,17	Very Good
	Average	4,28	Very Good

The mobile-app-based e-assessment, oriented towards science literacy and having undergone validation and revision, was subjected to a limited trial to determine its practicality. A product is considered theoretically practical based on the perceived user experience. The collected data was then converted into practicality criteria. The analysis reveals that the developed product falls into the "very good" practicality category, with 85% positive responses indicating its practicality.

Mobile assessment, as part of mobile learning, offers users convenience, easily accessible learning resources, and supports students' psychological readiness for tests[9]. In higher education, most students consider mobile assessment platforms to be convenient assessment tools. College students, in particular, express interest in using mobile assessment platforms, which can aid in adopting new assessment techniques, ultimately making the assessment process easier. Results indicate that the primary parameter driving student use of mobile assessment platforms is system quality. If users find high system quality, their willingness and intention to properly use new assessment approaches will increase [10]. Therefore, the product developed in this research will continue to be evaluated to achieve high system quality and ensure a positive impact.

The mobile-app-based e-assessment, focused on science literacy and having undergone validation and revision, was subjected to a limited trial to assess its practicality. Theoretical practicality is determined by user perception, with collected data converted into practicality criteria. Analysis reveals the developed product falls into the "very good" practicality category, supported by 85% positive user responses.

Mobile assessment, integrated into mobile learning, offers convenience, accessible resources, and supports students' psychological test readiness [9]. In higher education, it's viewed as a convenient tool, with students expressing interest in its use for adopting new assessment techniques, simplifying the process. Research indicates system quality is the primary driver of mobile assessment platform adoption [10]. High system quality increases users' willingness to adopt new assessment approaches, thus, continuous evaluation is crucial for the developed product to achieve high quality and positive impact.

The presence of mobile-based assessment tools positively influences learning. Mobile devices enable low-cost evaluations, motivate learners, foster skills, and encourage participation in problem-solving. E-assessment also facilitates immediate data management by collecting student scores and providing educators insights into their learning progress [14]. The use of technology in assessments allows for flexibility in terms of time and location.

Table 4. Results of the Extensive Trial

No	Aspect	Score	Category
1	Material	4,39	Very Good
2	Language	4,36	Very Good
3	Display (Design)	4,45	Very Good
4	Software Engineering	4,38	Very Good
	Average	4,39	Very Good

The implementation of the mobile-app-based e-assessment, focused on science literacy, proceeded smoothly and was rated as "very good." This effectiveness is supported by positive user feedback from students. The assessment process was simplified, requiring less time, effort, and budget compared to traditional paper-based methods. Paper-based assessments often face challenges such as the need to reproduce numerous questions, distribute them, and other logistical issues, making them less effective and efficient. Computer-Based Tests (CBTs) offer improved efficiency in question packaging [15]

The effectiveness of the e-assessment is evident in the calculated gain index, revealing a difference in students' literacy improvement between the experimental group using the mobile app (index of 0.64) and the control group using conventional methods (index of 0.56). While both groups showed moderate improvement, the experimental group experienced a significantly greater increase. This highlights the effectiveness of the mobile-based e-assessment compared to traditional methods. Linear regression analysis further supports this, with a significance value of 0.00, confirming the positive influence of the mobile-based e-assessment on science literacy. The R2 value of 0.95 indicates that 96% of the variation in science literacy can be explained by the use of the e-assessment.

Utilizing mobile devices in learning is promising for improving student achievement, motivation, and interest. This increased motivation also contributes to smoother learning and evaluation processes. Integrating technology into education appeals to students in the digital age, and traditional learning methods are gradually being replaced as technology advances. Additionally, the assessment process has become faster and easier with the use of technology [16].

E-assessment serves a crucial function in education, notably by addressing the weaknesses of traditional paper-based assessment systems. It offers benefits such as reduced assessment time, provides high-quality data for teachers and administrators,

and lowers printing costs [17]. Educators' feedback indicates that the mobile-app-based e-assessment aids objective evaluation and effectively measures science literacy. The results are generated in real-time, without bias towards students' names, race, culture, or background. Computers enhance assessment objectivity [18]. Furthermore, implementing mobile learning contributes to developing future teachers' competence in effectively utilizing technology [19].

While relatively new in higher education, e-assessment is transforming assessment practices and is poised to play an increasingly significant role in the future [20]. Research reveals various examples of automated electronic assessment practices and tasks. Automated e-assessment saves assessors' time and facilitates immediate feedback to students on their achievements, which has proven beneficial [21].

E-assessment has garnered growing interest in the research community due to the changing nature of higher education and expectations for its practice [22, 23]. Factors driving this interest, including its potential and the challenges facing higher education today. He emphasizes the importance of fair assessments that do not disadvantage students and highlights the need for research on pedagogical principles, design, and frameworks to fully utilize e-assessment for student learning and educator effectiveness [24].

The use of technology in assessments can enhance assessment practices and stimulate innovative approaches to assessment design in higher education [23]. A renewed focus on electronic assessment driven by pedagogy rather than technology. This research review reveals that this development is primarily enabled by higher-order abilities, including science literacy [25].

4. Conclusion

Based on the research findings and discussion, it can be concluded that the mobile-app-based e-assessment product oriented towards science literacy has been successfully developed and declared suitable for use based on expert assessment with an Aiken's V score of 0.89. Initial trials indicate that the application is easy to use and does not encounter significant obstacles on several tested mobile devices.

This research is still in the data collection stage to measure the practicality and effectiveness of the application more comprehensively through field trials involving more users and mobile devices. Nevertheless, the promising initial results indicate the great potential of this application in improving the science literacy of prospective science teachers.

Further research can be directed towards expanding field trials, in-depth analysis of practicality and effectiveness data, and further exploration of the impact of this application on student motivation and learning outcomes. Development of additional features and improvement of system quality can also be the focus of further research.

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