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Improvement of students' digital literacy through the development of android-based Smart Edu learning media on plant breeding material

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ABSTRACT

This study intends to increase students' digital literacy abilities through the implementation of Smart Edu learning media in plant breeding material. This is a research and development project. Peer reviewers, material specialists, media experts, and student trials are used to evaluate products. Digital literacy and media assessment questionnaires were used to gather research data. The investigation's findings are: 1) According to scientific phases, the Android-based Smart Edu learning media was created, and its features include an eye-catching visualization display, user friendliness, and content that aligns with the goals of plant growth and development; 2) according to material expert tests, android-based Smart Edu learning media on plant growth and development material that has been developed is suitable for use in learning when viewed from the perspective of content assessment or the learning material's contents, which are included in the very good category; 3) learning with android-based smart edu media has significantly improved digital literacy when compared to conventional learning. The development and application of Android-based smart educational learning materials demonstrate that their use is both practical and efficient in enhancing students' digital literacy. Further study should be done to create iOS and Android-based applications as well.

INTRODUCTION

Humans must continue to develop their abilities and skills in the current globalization era of science and technology in order to compete both nationally and internationally (Hani & Suwarma, 2018; Rahman, 2023). The demands of a globalized society force the education sector to constantly change to technological advancements in an attempt to raise the standard of instruction. This is particularly true when it comes to modifying how information and communication technology is used in the classroom. Nowadays, people view technology as being crucial to human existence because it helps with a variety of tasks, including job and education (Agustian & Salsabila, 2021; Promrub & Sanrattana, 2022).

Humans' capacity to use technology to fulfill daily needs, including educational activities, has increased because to the swift advancement of information and communication technology (Novriani et al., 2021). As technology advances, those with the aptitude and know-how to handle issues in a digital setting will be increasingly in demand. We refer to this skill as digital literacy. Digital literacy is defined as a person's ability to comprehend and apply information in various formats, with an emphasis on critical thinking rather than the use of information technology, in order to improve learning planning, knowledge insight, and learning outcomes (Chen et al., 2018; Raygan & Moradkhani, 2020).

Information processing, cognitive, and socioemotional abilities are linked to digital literacy and are crucial for students to successfully complete activities in digital contexts (Kaeophanuek et al., 2019). In order to gain new insights, create multimedia representations, interact with peers in real-life scenarios, and explore, retrieve, organize, combine, evaluate, research, and combine digital materials, one must possess digital literacy (Cohen et al., 2020; Falloon, 2020; Marini et al., 2020; McKinstry et al., 2020). Using digital literacy to provide suggestions, comments, and accounts of specific educational themes might support learning efforts in digital communication. Therefore, in order to survive and thrive in the quickly evolving digital age, one must be proficient in both technology and information.

Research on digital literacy skills is still crucial, especially for developing nations like Indonesia. The usage of learning media in science disciplines is still restricted to PowerPoint and torsos or props, according to preliminary observations made at the Mts Istiqlal Jakarta school. Although Android is widely utilized by students and instructors, MTs Istiqlal pupils have never used Android applications as a learning tool. When PowerPoint is used as a teaching tool, the focus of continuous learning remains on the teacher, which can easily dull pupils throughout class and affect their cognitive development.

This indicates that Mts Istiqlal Jakarta is still behind in empowering students to use Android-based digital media in the classroom when it comes to learning media implementation. Students that possess digital literacy skills are better equipped to develop critical thinking skills and, as a result, become more mature and aware when it comes to creating, communicating, and consuming information (Yasdin et al., 2021). Digital media integration in the classroom may foster greater experiences of students' self-efficacy, which may have an impact on their cognitive functions and self-assurance (Marci-Boehncke & Vogel, 2018). The outcomes of a study Lubis et al., (2019) that used SMS GATEWAY on a smartphone to remotely operate the water machine. An Android smartphone and an Arduino Uno are connected by wireless communication, and the Arduino Uno is a device that transmits data automatically.

Technology-based learning resources need to be developed and put into use in these schools in order to raise the level of digital literacy among students who have now stepped into the digital era. Thus, the primary goal of this research is to develop an intelligent educational Android application that will assist Mts Istiqlal Jakarta students in gaining more digital literacy. Smart education applications for Android can automatically and instantly offer data information. Real-time data production can be applied to learning and plant breeding techniques. With the help of intelligent educational Android applications, students can occasionally monitor plant progress.

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METHODS

This study makes use of Thiagarajan's 4D model, which was created through research and development (R&D) (Thiagarajan & Semmel, 1974). The created device is an Android-based Bio Edu learning media device for plant breeding material. The four phases of the 4D model are define, design, develop, and disseminate.

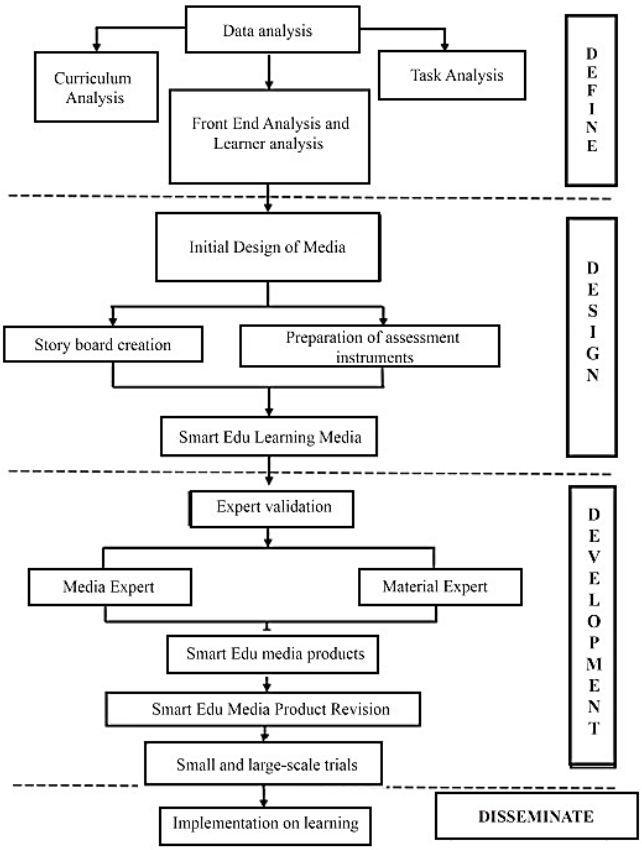

Figure 1. Development research procedures

There are four steps in the research process: 1) Define, including the preliminary needs analysis needed for the design stage; 2) Design, including the creation of instruments for measuring digital literacy and media viability as well as the development of Android-based Smart Edu learning materials based on the needs analysis that has been completed; 3) Development, which includes creating Smart Edu learning materials based on Android and testing the viability of the project on two validators: material experts and media expert validators. After development, the learning materials are tested, and this includes distributing the Android-based Smart Edu learning materials, which were first created on a modest scale and then refined. The media was then evaluated on a broad scale, 4) Disseminated, and finally implemented Android-based Smart Edu learning media to assess the effectiveness of students' digital literacy. Figure 1 depicts the research process.

This study was conducted at MTs Istiqlal Jakarta during the 2023/2024 academic year. The population considered is all class IX students at MTs Istiqlal Jakarta. Students in class IX served as the research sample for this study's product testing. The limited trial sample (first product) consisted of 15 students from class IX who were chosen using particular criteria. The main product's field trial subjects were class IX students, with a total of 50 students chosen using purposive sampling.

This data was gathered using four Likert scale parameters and a closed questionnaire instrument. This is done to make it easy for respondents to respond to the questionnaire, whether

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they agree or disagree. The data collection instrument uses a digital literacy skills questionnaire. The digital literacy skills questionnaire items are structured based on seven digital literacy components (Hague & Payton, 2011). The seven indicators of digital literacy are ICT abilities, searching and selecting information, creativity, collaboration, communication, critical thinking and evaluation, and e-safety. Table 1 displays the assessment indications along with a description.

Tabel 1. Digital literacy instrument

No.	Indicator		Description
1.	ICT abilities	4	Students are able to operate and recognize the Android-based learning applications used, as well as turn on and off computer devices.
		3	Students are able to utilize computers, recognize them, and turn them on and off.
		2	Students have the ability to recognize, turn on, and turn off computers
		1	The computer can be turned on and off by students
2.	Searching and selecting information	4	Students can look up references on YouTube, blogs, Wikipedia, and journal publications
		3	Students can use blogs, journal papers, and Wikipedia to find references
		2	Students can use blogs and Wikipedia to look up resources
		1	Wikipedia can be used by students to find references
3.	Creativity	4	Students can use Canva to design assignment covers, make slides in PowerPoint, build tables in Microsoft Excel, and complete assignments in Microsoft Word
		3	Students have access to Microsoft Word for assignments, Microsoft Excel for creating tables, and PowerPoint for creating slides
		2	Students can use Microsoft Excel to build tables and Word to complete homework
		1	Students can use Microsoft Word to complete assignments
4.	Communicate	4	Students actively participate in in-person, virtual, and blended learning conversations
		3	Students actively participate in both in-person and virtual conversations
		2	Students actively participate in face-to-face talks
		1	Students participate actively in internet forums
5.	Collaborative	4	Students can participate actively in Q&A sessions, work together on learning platforms, organize study groups, and exchange educational materials
		3	Students can work together on learning platforms, join study groups, and exchange educational materials.
		2	Students can form study groups and exchange knowledge
		1	Students are able to form study groups
6.	Critical thinking and evaluation	4	I am capable of making use of and putting into practice a variety of digital learning platforms that are linked to the Smart Edu learning resources
		3	I am able to access and make use of a variety of digital learning platforms that are linked to the Smart Edu learning resources
		2	I have access to a variety of digital learning platforms that are integrated with the Smart Edu learning resources
		1	I simply use digital media
7.	E-safety	4	Students understand privacy when using the learning platform, use personal emails when registering on the application, and are careful when writing comments on the learning platform
		3	Students understand privacy when using the learning platform, use personal email when registering on the application
		2	Students understand privacy when using the learning platform, and do not use personal emails when registering on the application
		1	Students understand privacy when using the learning platform

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Validity and reliability tests are the first steps in the test evaluation process before the instrument is employed. The results of the validity test of 35 of the 50 items were declared valid. Concurrently, the reliability test yielded a very high category correlation coefficient of 0.90. This test uses tools in the form of the Question Item Analysis application in Microsoft Excel format.

The following steps were taken in the analysis process: (a) Converting the checklist validation sheet data results into quantitative data in the form of Likert scale scores. This is done to facilitate respondents' ability to respond to the questionnaire, regardless of whether it is practical or not. (b) Use the equation to determine the total number of scores on the validation sheet. Each aspect's value is determined by dividing the maximum score by 100, which is generated from the answers to the indicators that were investigated and deemed to be the most appropriate. The total value of each indicator divided by the number of indicators yields the average value of each aspect; and (c) Translate the percentage score for each acquired aspect to the score interpretation criteria listed in Table 2 (Widoyoko, 2013).

Tabel 2. Score interpretation

Percentage	Category
71 – 100	Very good
61 – 80	Good
41 – 60	Sufficient
21 – 40	Poorly
0 – 20	Extremely poor

RESULTS AND DISCUSSION

Investigation and creation of educational materials for Android According to the 4D research approach, Bio Edu was conducted in four stages: define, design, develop, and distribute. In this section, research data is presented and elaborated with related theories and relevant research results. Results and discussions are made in one continuous unit. Results should be clear and concise. If there is more than one research parameter, several subheadings can be created.

Define

The describe stage is the first step in creating learning materials for Bio Edu that are based on Android. The define stage consists of the following five steps:

Analysis of the Front End

At this point, MTs Istiqlal Jakarta conducts a diagnosis of Biology Science learning. The study employed interview approaches to gather information from Biology Science teachers at MTs Istiqlal Jakarta's class IX. The analysis focused on the usage of learning media and the application of learning strategies. Based on the findings of the interviews, science teachers frequently utilized pointers and props, such as torsos, as learning aids. Because the teacher still serves as the primary information source during the learning process, there is a perception that the usage of learning media is not ideal.

Analysis of Learners

During the learner analysis stage, a diagnosis was made about the ways and strategies that 12 class IX students at MTs Istiqlal Jakarta often utilize to find knowledge sources during the learning process through interview approaches. Ninety percent of students stated that they used the student handbook when looking out information sources. Students are more likely to feel bored and incapable of doing in-depth analysis when they use media for knowledge retrieval

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infrequently. These findings indicate that, via the use of a variety of learning media, a learning medium is required that can engage students actively and foster a deeper sense of wonder.

Work Analysis
During the task analysis stage, a review of the primary actions that students need to take in order to grasp the fundamentals of the subject matter—particularly plant reproduction—is conducted. Indicators of science learning outcomes are being created at this point, particularly in plant breeding material.

Idea Evaluation
In order to attain students' basic proficiency, the Concept Analysis step involves analyzing the concepts of the material that will be taught to them. At this point, tasks include analyzing the topics taught and planning the next course of action. The analysis's findings can be used to establish the requirements for utilizing the upcoming media.

Determining the Instructional Goals
The learning objectives that students will acquire after the lesson are now identified, particularly about plant breeding material. Learning objectives are a useful tool for assessing how well learning has been done. It can be argued that the learning process is ineffective or unsuccessful if the learning objectives are not met.

Design
The first step in the process of building Android-based Bio Edu learning materials was designing the platform's initial design. The first step in the design process is making a storyboard. The purpose of storyboards is to facilitate the development of educational materials. Creating a storyboard can also help identify the next phase of development, allowing components to be properly organized. The layout is then created using the storyboard as a guide. When creating layouts, consideration is given to color and composition. After the layout is finished, different supporting functions are added. The goals and learning resources gathered during the Concept Analysis stage guided the creation of the Android-based Smart Edu learning modules.

Development
After the storyboard and layout creation stages are complete, the next stage is the learning media development stage. This stage aims to develop software for Android applications and hardware in the form of sensors on planting media. The Flutter platform was utilized in the development of application design for the construction of Smart Edu learning media for Android. After that, sensors placed on the planting media will be linked to the planned learning media. In addition to controlling the irrigation system, which is directly connected from the Smart Edu application to irrigation in the plantation, this media design is utilized to see the results of sensor readings**.**

The Smart Edu Android-based learning media is designed with features that facilitate students' access to data and a minimalistic look. Android Studio is used for Android application design. It allows the creation of multiple interfaces that can be displayed in the application. Additionally, it allows the creation of a page that shows all of the data connected to the Arduino microcontroller device. This is achieved by using the data request feature adapter to display data in list form and by using the recycler view to view data updates. The Smart Garden application's login, register, and profile display looks like this:

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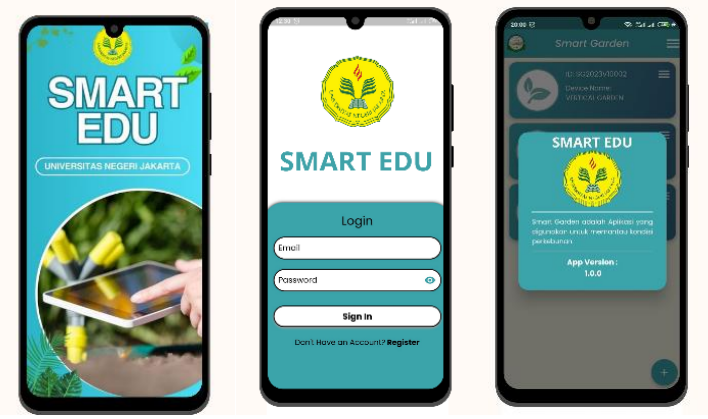

Figure 2. Smart Edu learning media display

Expert Validity

Following acquisition of the learning media development, it is created in accordance with the story board design, and specialists then validate it. The purpose of product validation is to assess whether the generated application product is suitable. Following are the results from several experts in the Table 3.

Table 3. Media expert test validation results

No	Aspect	Question Items	Average	Percentage
1.	Learning media display	1,2,3,4	19,3	97%
2.	Smart Edu media menu	5,6,7,8	19,0	95%
3.	Easy to use	9,10,11,12	18,0	90%
4.	Usefulness	13,14	9,3	93%

The Smart Edu learning media generated has an average percentage score of 92.4%, placing it in the Very Good (SB) category, according to validation by media experts. Users can easily utilize learning media as a way to monitor plant growth and development activities thanks to the features included in Smart Edu Android-based learning media.

Table 4. Material expert test validation results

Aspect	Question Item	Average	Percentage	Category
Smart Edu media content	1,2,3,4	19,0	95%	Very capable
Language	5,6,7,8	18	90%	Very capable
Digital literacy	9,10,11,12	19	95%	Very capable

Product revision

After the expert validation stage was carried out, the Smart Edu learning media had its deficiencies corrected based on the advice given by the expert. Some of the suggestions given include 1) adding pictures of the material that can increase students' curiosity, and 2) using the same material template to make it easier for students to understand the flow of the material. Next, product revisions are carried out according to suggestions and input provided by expert testers. The improvements made are by adding images and replacing the appropriate material layout so that the Smart Edu learning media created is ready to be implemented in the learning process.

Disseminate

Smart EDU learning media are used to collect data on the effectiveness of the learning media employed. Percentage of digital literacy skills can be seen in Table 5.

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Table 5. Percentage of digital literacy skills

No	Aspect	Average	Percentage	Category
1.	ICT abilities	3,82	96 %	Excellent
2.	Searching and selecting information	3,65	91 %	Excellent
3.	Communication	3,62	91 %	Excellent
4.	Creativity	3,76	94 %	Excellent
5.	Collaborative	3,72	94 %	Excellent
6.	Critical thinking and evaluation	3,74	94 %	Excellent
7.	E-safety	3,64	91 %	Excellent

Using Android-based Smart Edu learning resources in the classroom to supplement lessons on plant breeding constitutes the diffusion stage. This section is the main part of the research result article in which the final results are presented. The data analysis processes, such as statistical computing and hypothesis testing, are not necessary to be served. The materials reported are the analysis results and hypothesis testing results. In addition, tables and figures are also can be shown to enunciate the verbal narration. Tables and images must be given a comment or discussion. The details of qualitative research are written in some sub-topics which directly related to the focused category.

1. ICT abilities

Based on the results of the questionnaire, it was determined that 96% of pupils could operate laptop computers extremely effectively. The times' increasingly sophisticated development demonstrates that students are well-versed in the rapidly advancing technologies of today. ICT abilities can be seen in Figure 3.

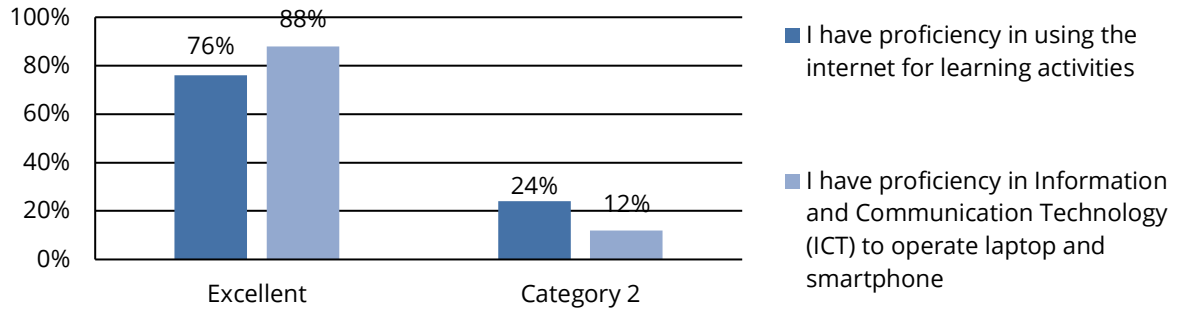

Figure 3. ICT Abilities

Based on Figure 3, it is known that 76% of students have excellent skills in using the internet in the learning process, and as many as 24% of students have good skills in using the internet in the learning process. This illustrates that students' ability to use the internet in the learning process is very good.

In the next question, it was discovered that 88% of students had Excellent abilities and 12% had good abilities in the field of information and communication to be able to operate laptops and cell phones. Based on these findings, the ICT Skills component determined that the respondent possessed internet-related ICT skills and very good computer operating abilities. The millennial generation uses computers and the internet with proficiency. Considering that nearly every student owns a smartphone and spends the majority of their time online, this is typical (Kurniawati & Baroroh, 2016).

2. Searching and selecting information

Figure 4 demonstrates that most students "strongly agree" with the component's capacity to find and choose relevant information.

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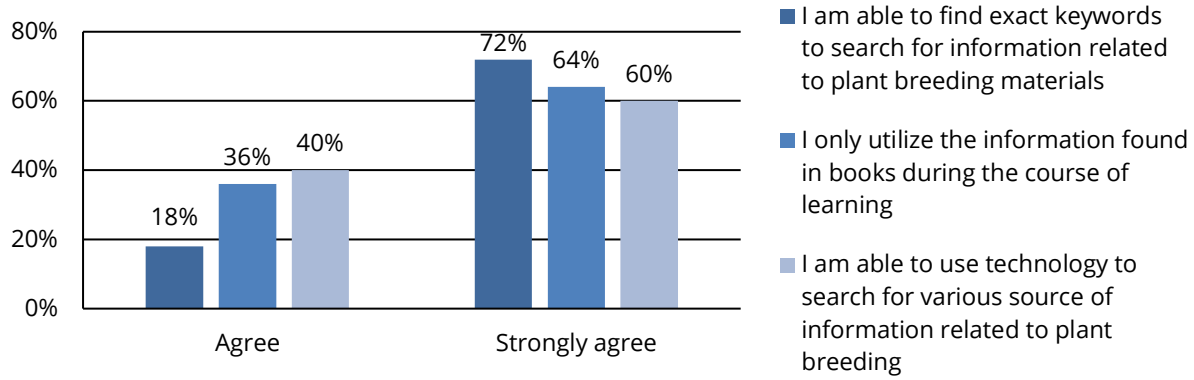

Figure 4. Aspect Searching and Selecting Information

Based on Figure 4, 60% of respondents strongly agree and 40% of respondents agree that they can find the right keywords when searching for information related to plant breeding material via the internet. Based on the graph, it is known that 64% strongly agree and 36% agree that respondents can find information about learning using books during the learning process. In other aspects, it is known that 72% of respondents said they strongly agreed and 18% agreed that they could use technology to search for various sources of information related to plant breeding material. Based on the graph, shows that most students stated "strongly agree" regarding the ability of the components in searching for and selecting information to use.

According to Martin (2008), digital literacy is an individual's ability to use digital tools appropriately so that he is facilitated to access, manage, integrate, evaluate, analysis digital resources in order to build new knowledge, create media of expression, communicate with other people in certain life situations to realize development. social, from several forms of literacy, namely: computers, information technology, visual, media and communication.

This skill can improve a person's ability to deal with digital media, both accessing, understanding content, disseminating, creating and even updating digital media for making decisions in their life. If someone has these skills then he can use digital media for productive activities and self-development, not for consumptive or even destructive actions.

3. Communication

The communication aspect of the learning media developed is seen in Figure 5.

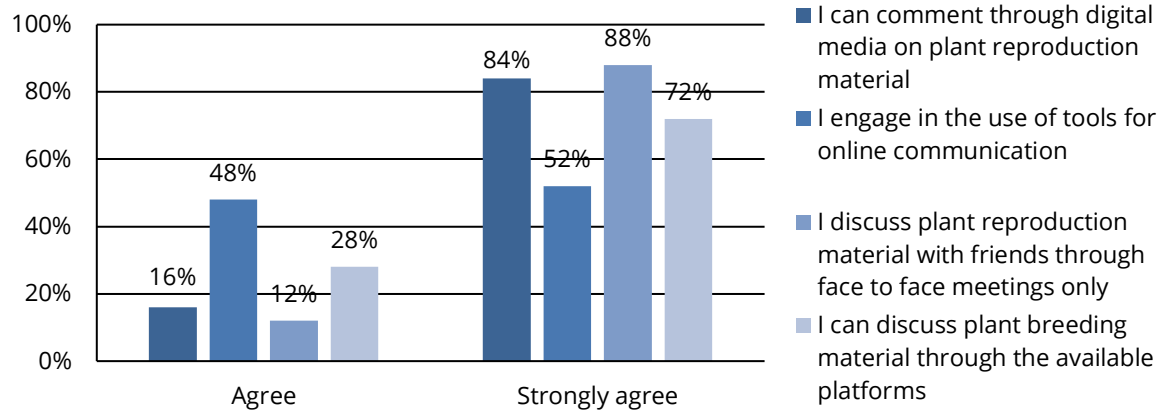

Figure 5. Aspect communication

A feature that allowed users to remark on learning media was included in the learning media generated, according to the graph, which indicates that 84% of respondents highly agreed and 16% agreed. Students can react to the material presented in the created learning media thanks to this feature. The smart Edu learning medium also offers the ability to debate the offered learning

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material, as indicated by 84% of respondents who strongly agreed and 16% of respondents who agreed.

In response to the following question, data showed that 52% of respondents said they highly agreed and 48% said they agreed that adopting this learning medium would enable them to actively use communication channels that could be immediately connected online.

Student communication can be enhanced through the use of Android-based Smart Edu learning materials for plant breeding material. These results support the notion that responders possess high interpersonal comprehension, negotiation of viewpoints, and digital media communication skills. Respondents' adept communication abilities are inextricably linked to their practice of utilizing cellphones as a communication tool since they are accustomed to, and daring to, share their opinions and listen to others via digital media.

4. Creativity

Based on Figure 6, students' creative abilities in using digital literacy have positive results.

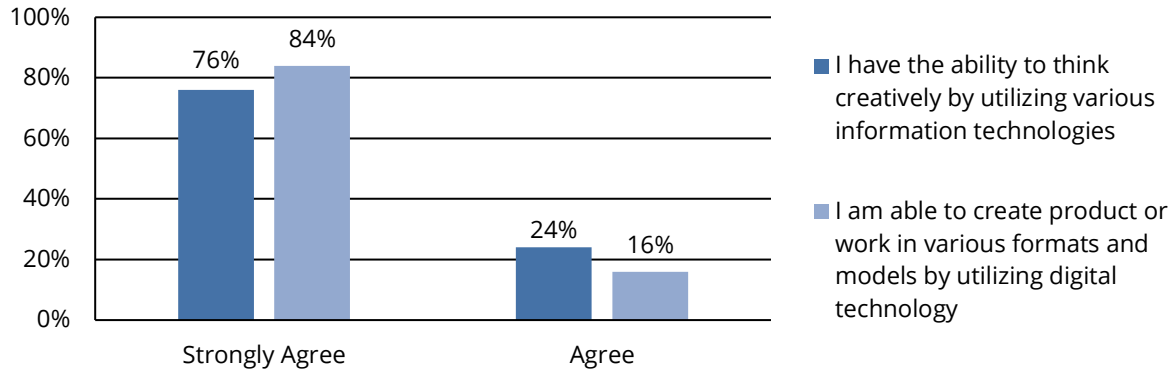

Figure 6. Aspect Creativity

Figure 6 indicates that 16% of respondents and 84% of strongly agree respondents, respectively, believe that using different digital information technologies in smart EDU learning media helps to improve creative thinking skills. Through the Smart Edu application, students can use digital technology to be creative in a variety of formats and models. Additionally, 24% and 76% of respondents, respectively, agreed and strongly agreed that they may use their creativity to think imaginatively in order to obtain knowledge from a variety of technologies, including Smart Edu.

In their article Digital Literacy across the Curriculum, Hague & Payton (2011), explain that digital literacy is a person's ability to apply functional skills to digital devices, enabling people to find and select information more quickly and efficiently, improve critical thinking, and increase creativity. Collaboration with other people becomes easier, means of communication become more effective and efficient, and maintains security from an electronic point of view and a social and cultural development education perspective

From the perspective of the world of education, good digital literacy will play an important role in developing knowledge about the material involved. both in certain areas of learning by increasing children's curiosity developing children's creativity, to broadening children's way of thinking, so that they have broader thoughts and ideas. Digital literacy using learning media is a new step in forming students' abilities to think logically, analytically, critically, imaginatively, innovatively, creatively, and effectively (Selegi & Aryaningrum, 2022).

5. Collaboration

As can be seen in Figure 7, most respondents indicated that they "Strongly Agree" with relation to their talents in the teamwork component. These findings led to the conclusion that respondents were proficient at articulating concepts and interacting with others online.

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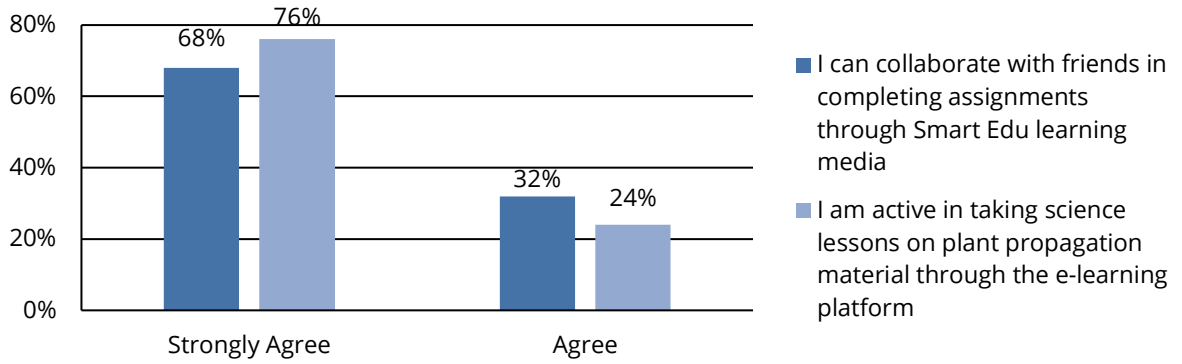

Figure 7. Aspect Collaborative

Based on Figure 7, 24% of respondents and 76% of respondents strongly agree that cooperation should be implemented through Smart Edu learning media. Additionally, a majority of 68% of participants expressed strong agreement, while 32% of respondents felt that they could actively engage in learning using the Smart Edu platform.

Students can complete tasks in collaborative study groups with their friends using Smart Edu learning resources. Aside from that, students actively use the plant breeding resources available on the Smart Edu e-learning platform. Through the Smart Edu application, students exchange knowledge and actively participate in Q&A sessions that take place during instruction. Students use this skill to engage in teacher-facilitated learning using smart EDU learning materials. These results suggest that respondents are skilled at explaining ideas and communicating with others on the internet.

Students who are literate are much more likely to acquire effective communication skills, the ability to collaborate, work in a variety of teams, and build interpersonal relationships. Students who possess these abilities can consistently arrange themselves in concordant situations (Amin et al., 2023; Setiyadi et al., 2022).

6. Critical thinking and evaluation

As can be seen in Figure 8, most respondents said they "Strongly Agree" with the utilization of Smart Edu learning materials to enhance critical thinking and evaluation skills. These findings support the notion that pupils are proficient at critically assessing and thinking about the knowledge that already exists. Students can assess the quality of search results to ascertain the source's credibility, the information content's utility in the search process, and more (Marini et al., 2020),

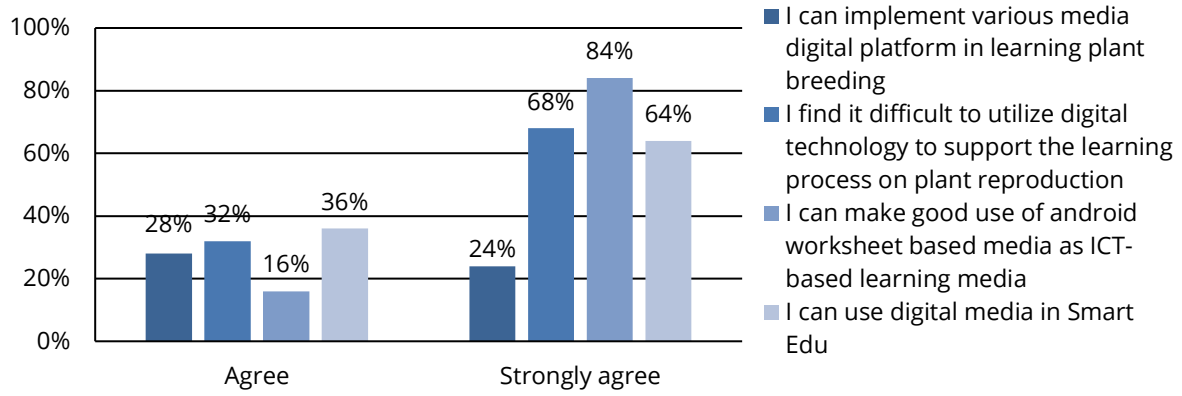

Figure 8. Aspect Critical thinking and evaluation

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According to Figure 8, which shows that 36% of respondents and 64% of respondents strongly agree, students can use digital media in Smart Edu. Students can utilize the electronic worksheet which is available in Smart Edu, with 16% of respondents agreeing and 84% strongly agreeing. Then, 16% of respondents agreed and 60% of respondents strongly agreed that they had trouble using technology to aid in the process of studying plant breeding material. Out of the students, 28% agree and 72% strongly believe that they have technical knowledge of digital technology. Critical thinking also includes the ability to synthesize and filter numerous arguments and information so that it may be accepted correctly (Amin et al., 2023).

According to Nana (1995), achievement of learning outcomes is influenced by 2 factors, namely internal factors where these factors come from oneself, and external factors, one of which comes from the school environment where the type of learning effort used by educators and students is learning media to support learning that functions to convey the content and message of the material (Nurwidayanti & Mukminan, 2018).

7. E-Safety

The results of respondents' answers regarding the e-safety component are shown in Figure 9. Figure 9 shows that the majority of respondents stated "Strongly Agree" regarding the capabilities of the e-safety component.

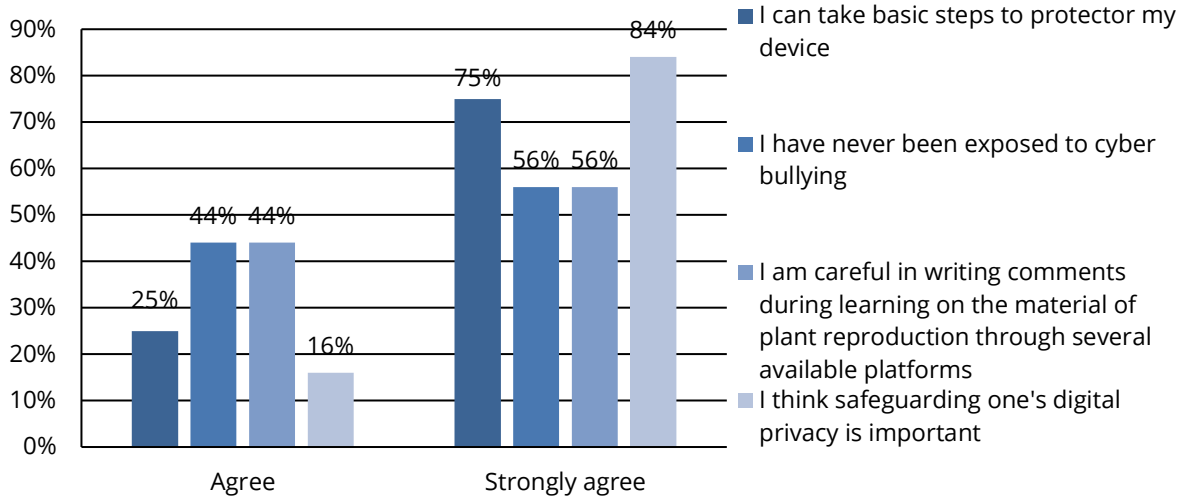

Figure 9. Aspect E-Safety

Students are well-versed in the privacy implications of utilizing digital devices. According to Figure 9, 16% of respondents and 84% of strongly agree that safeguarding one's digital privacy is important, even when utilizing the Smart Edu program. remarking on the knowledge that students are gaining about plant breeding using the Smart Edu platform and other online resources. The data indicates that 44% of respondents agree and 56% strongly agree. Being able to use caution when making comments is crucial in order to prevent certain people from taking advantage of you. Then, 44% of respondents agreed that they had never been bullied, and 56% of respondents strongly agreed. There is also a fundamental understanding of device protection among students, with 25% disagreeing and 75% strongly agreeing.

These are the kinds of abilities that every child and adolescent who interacts online needs to be taught. On the other side, the irreversible nature of ICT (information and communication technology) development makes the socialization of e-safety imperative. When accessing the internet or other online resources, students who possess a sufficient level of digital literacy can identify the risks and drawbacks (Helsper & Smahel, 2020; Ruenphongphun et al., 2021).

The development research yielded a product whose efficacy gauges MTs Istiqlal Jakarta pupils' digital literacy, particularly in class IX. These findings demonstrate that Smart Edu's products may improve students' digital literacy and are appropriate for use in the classroom. In

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order to help people comprehend the hazards involved with using technology and take the necessary precautions to protect themselves and their privacy, it is crucial that students have a solid understanding of digital literacy. Strong digital literacy abilities are positively correlated with enhanced learning planning, more student insight, and improved learning outcomes. They will also make it simpler, faster, and more varied for students to obtain material from the internet (Raygan & Moradkhani, 2020).

CONCLUSION

Based on the research findings and discussions regarding the creation of Android-based Smart Edu learning materials, it can be concluded that the Smart Edu learning materials based on Android were developed according to scientific stages. Additionally, the visual presentation of the materials in Android-based Smart Edu learning media features attractive visuals, user-friendly interfaces, and content that aligns with the objectives of learning about plant breeding. Based on validation by expert teams, the content of the Android-based Smart Edu learning materials falls within the category of very good and is deemed suitable for use in learning. Learning using Android-based Smart Edu media has been proven to result in significant improvements in digital literacy compared to traditional learning.

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