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Innovation Of Mobile Virtual Laboratory As A Learning Facility

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Abstract

The presence of Informatics subjects is a response to preparing human resources (HR) who can adapt to the industrial revolution 4.0 and society 5.0. Unfortunately, there are obstacles in implementation, especially related to computer laboratory facilities. So innovation is needed that can help schools implement Informatics subjects so that students can have adequate digital literacy in facing the industrial revolution 4.0 and society 5.0. The aim of the research is to develop and test the feasibility of being an Informatics learning facility for high school students in Pontianak City, as well as seeing the students' response to the mobile virtual laboratory. The method used is Research and Development (R&D), with a development design using DDD-E. Research subjects consist of development subjects, namely design experts, media experts and material experts and students to determine the response to the media being developed. Data analysis techniques use a data analysis approach Qualitative and quantitative. The results of the research are that the media was developed using DDD-E, the suitability of the media based on material experts and media experts is in the very good category and suitable for use. Student responses to the media that have been developed are very good for use.

INTRODUCTION

In 2022, the Ministry of Education and Culture has published a new curriculum, namely the Merdeka Curriculum (KM), which aims to accelerate the realization of national education goals (Minister of Education, Culture, Research and Technology, 2022a). Apart from that, KM is also intended to prepare human resources who can adapt to global challenges in the era of revolution 4.0 and society 5.0 by strengthening character education through the Pancasila Student Profile. One of the most visible changes to realize the goals of KM is the return of the Informatics subject which is a refinement of the ICT subject in the 2013 Curriculum (K13) which is only integrated into various

other subjects as well as in the Educational Unit Level Curriculum (KTSP) which is a stand-alone subject (Alhapip & Ferdiana, 2020).

Informatics subjects are the answer to overcoming the low digital literacy of students in Indonesia. Digital literacy is not only skills in using ICT tools but also being able to analyze, evaluate and create using various ICT tools (Sulistiyarini & Sabirin, 2020). Survey results related to digital literacy show that people in Indonesia only use technology (World Economic Forum, 2015), this situation is in line with other surveys which state that less than 30% of Indonesian people have basic skills related to ICT and for specific ICT skills amounting to less than 3% (Ministry of Communication and Information of the Republic of Indonesia, 2019). Research conducted by several researchers shows that the ICT skills of people in Indonesia do not yet meet the standards required by industry (Mirfani, 2019; Nafi'atul Huda & Lestari, 2018), furthermore other research estimates that Indonesia needs to prepare 9 million skilled workers in the ICT field capable until 2030 (Tan & Tang, 2016). For this reason, the role of Informatics subjects is very central as a driving locomotive to achieve better digital literacy.

Informatics subjects in KM have different content from ICT subjects in the previous curriculum. Previously, ICT subjects had two paradigms, namely ICT as a learning aid (ICT for learning) which was implemented in K13 and ICT as learning material (Learning ICT) which was implemented in KTSP. The Informatics subject at KM not only studies ICT but also includes computational thinking as a theoretical basis which is implemented in five fields of science, namely computer engineering, computer networks/internet, data analysis, algorithms and programming as well as the social impact of informatics, and ICT as a creativity tool, collaboration, and innovation (Alhapip & Ferdiana, 2020). Based on this foundation, the Informatics subject in KM has eight elements, namely Competitive Thinking (BK), Computer Engineering (TK), Computer Networks/Internet (JKI), Data Analysis (AD), Algorithms and Programming (AP), Social Impact of the Internet (DSI), Cross-Sector Practices, and ICT.

The eight elements in the Informatics subject are a combination of theoretical and practical material (Minister of Education, Culture, Research and Technology, 2022b). The BK, TK, JKI, and DSI elements are elements that are studied theoretically. BK elements study how computing is done in an efficient and optimal way, as well as TK which discusses computer components and operating systems, while JKI studies concepts about computer networks, communications and data security, and DSI studies the impact of informatics on the economic field. law, information disclosure and various opportunities open in the field of informatics (source). Other elements such as ICT, AD, AP, and Cross-Field Practices are elements that are learned through practical activities. The ICT element studies the applications needed for work, the AD element studies the use of applications to collect, manage, analyze and present large volumes of data, while the AP element studies how to create programs by applying computational thinking strategies, and cross-field practices are carried out collectively. Collaborative with other subjects to create or design solutions to social problems using applications.

The return of Informatics subjects to KM was welcomed by schools in Indonesia as seen from data from the Ministry of Education and Culture which shows that more than 140 thousand schools in Indonesia have implemented KM (Ministry of Education and Culture of the Republic of Indonesia, 2023) which can be interpreted as saying that The school is ready to implement Informatics subjects as one of the compulsory subjects. However, it cannot be denied that there are

various challenges to implementing Informatics subjects in every school in Indonesia. One of the big challenges in implementing the Informatics subject is the readiness of school facilities for the Informatics subject, especially regarding computer laboratory rooms, computers, licenses for applications, and internet networks. This situation is reflected based on an interview with the Deputy Principal of Walisongo Private High School which is still implementing K13. Based on this interview, it is known that one of the main reasons why KM has not been implemented is that there are no computer laboratories, teaching staff or computer equipment. This situation certainly does not only occur at Walisongo Private High School but also in various schools considering that not all schools have sufficient or sufficient laboratory facilities.

The problem of facilities is actually also one of the problems in schools which currently have made Informatics a compulsory subject, especially in schools that have large study groups. One of the schools experiencing this problem is SMA N 8 Pontianak which has a study group of 23 or 8 groups per generation. The large number of classrooms and limited laboratory space makes the Informatics learning process less effective. This is in accordance with an interview with a teacher at SMA N 8 Pontianak who stated that the hours for studying in the laboratory were only 1 JP (45 minutes) while 2 JP (90 minutes) were done in class because of limited computer laboratory space. Of course, this situation is less than ideal for Informatics lessons, even though there is material that is theoretical, but the theoretical material in Informatics subjects is generally abstract, for example in the BK element which studies data structures or JKI which studies data communication, of course it is difficult to understand if it is not visualized through practical activities. Meanwhile, practicum elements such as ICT, AD, AP, and cross-field practice are material that aims to improve skills and not to prove theory. For this reason, skill elements need to be carried out repeatedly so that students can acquire the skills needed and can become long-term knowledge for students (Apriyanto et al., 2022; Damanik & Anggraeni, 2022).

Another problem in the Informatics subject is support for independent learning by students. Informatics subjects can often only be studied at school and cannot be done at home because there are still many students who do not have personal computers. This situation is in accordance with a survey conducted by the Ministry of Communication and Informatics in 2019 which showed that only 8% of the Indonesian population had personal computers (Ministry of Communication and Information Technology of the Republic of Indonesia, 2019) while the latest survey from APJII in 2022 showed an increase with 11% of the population Indonesia which has personal computers (APJII, 2023). This situation is also reflected in students at SMA N 8 Pontianak, which based on a survey of 90 students showed that less than 5% of students had personal computers and only 24% of students whose families had personal computers. High School N 8 Pontianak students who frequently use computers outside of school are only around 12%, while those who occasionally use computers outside of school are around 44% and those who never use computers outside of school are around 43%. This data shows that there are still many students who only study Informatics at school and do not have the facilities to practice Informatics material independently.

Problems that occur in Informatics subjects certainly need appropriate solutions in order to encourage schools that have not implemented KM to implement KM so that students can study Informatics subjects which are really needed at this time. Apart from that, solutions are also needed to overcome informatics learning problems that are still not effective and can support independent learning for students. The solution that can be used to overcome this problem is to use a virtual

laboratory. Virtual laboratories are computer-based media that contain simulations or experiments to present phenomena that may or may not be visible in real situations (Hermansyah et al., 2015; Muhajarah & Sulthon, 2020). Virtual laboratory can also be interpreted as a medium that provides direct visualization of experiments, an interactive environment, carrying out practical activities, so that carrying out experiments becomes more efficient and can save on purchasing equipment (Ramadhan & Irwanto, 2018). Virtual laboratories can also be used as a solution due to shortage/absence of tools or materials, lack of laboratory assistants/teachers to teach, limited time to use the laboratory, and difficulty visualizing abstract concepts (Arista & Kuswanto, 2018).

Virtual laboratories in education are currently widely used, especially in science subjects. Various research results show that virtual laboratories can be used as substitute facilities for real laboratories (Bilah & Infantono, 2019; Rizal et al., 2018; Suryanti et al., 2019). The use of virtual laboratories in various research has been proven to have various advantages such as being flexible in setting the time and location of the practicum, the results of the practicum are immediately available and reliable, can be carried out repeatedly, there is no need to buy materials or tools, and the duration of the experiment is shorter (Gunawan et al., 2017; Jaya et al., 2020; Yuniarti et al., 2017). Other research also shows that virtual laboratories reduce practical activities with minimal work procedure errors and experimental handling errors, increasing work safety in the laboratory (Buchori & Pramasdyahsari, 2020; Widowati et al., 2017). In the learning process, the use of virtual laboratories has been proven to improve students' abilities in planning and problem solving, making learning time more efficient, supporting independent learning, and can be used to measure learning success (Gunawan et al., 2017; Masril et al., 2018) improving learning outcomes, critical thinking skills, and helping students understand concepts (Aripin & Suryaningsih, 2020; Chyntia Clarinda et al., 2022; Hikmah et al., 2017).

Based on various studies, Virtual Laboratory has many positive impacts and can be used as an alternative if the school does not have a laboratory. However, virtual laboratories generally require computers and a computer laboratory, while the problem faced by schools in the Informatics subject is the absence/lack of computers owned by the school. For this reason, innovation is needed in virtual laboratories so that they can be implemented in Informatics subjects. One form of innovation that can be carried out is developing a mobile-based virtual laboratory using a smartphone device. Smartphones currently have specifications that are capable enough to carry out computing activities such as computers or laptops so that they can be used as an alternative as a learning facility (Sulistiyarini et al., 2021). This is also supported by data from APJII which shows that 77% of Indonesian people have used smartphones with a penetration rate in middle school to high school age of more than 90%, which means that in 90% of middle school to high school students generally already use smartphones (APJII, 2023).

The use of Mobile Virtual Laboratory for lessons that focus on skills based on research shows good results even though not much research has been done. The use of a mobile virtual laboratory can reduce the costs required to create a skills laboratory which costs quite a lot (Triatmaja et al., 2021), making practical activities more flexible for gaining direct experience (Alharbi, 2018). Other research shows that the Mobile Virtual Laboratory can improve student learning outcomes, encourage the creation of the attitudes needed in carrying out practice, and create a safe environment in carrying out practice (Samosa, 2021). Other research also shows that mobile virtual laboratories can be used as a means for independent and group learning activities (Basuk & Ummah,

2020). However, when creating a mobile virtual laboratory, it is necessary to pay attention to compatibility and stability as well as technical support (Alharbi, 2018).

Based on the description of the mobile virtual laboratory, it can be used as a solution to overcome problems in the Informatics subject. Using a mobile virtual laboratory can be a solution for schools that do not yet have a computer laboratory but want to implement KM considering the importance of digital literacy for students. Meanwhile, for schools that have limited laboratories so that the learning process is less effective, they can use mobile virtual laboratories as a means to prepare students to understand the material and skills needed before using actual computer devices. Apart from learning activities at school, students can also use the mobile virtual laboratory for independent learning considering that the environment in the mobile virtual laboratory is made as safe as possible so that students do not need to be afraid of making mistakes. The use of mobile virtual laboratories can also support KM which provides opportunities for students with abilities to enrich material and students with low abilities to prepare themselves.

Apart from being based on the explanation that has been submitted, the Mobile Virtual Laboratory Innovation research as an Informatics Learning Facility for High School Students in Pontianak City is also in line with the Research Master Plan (RIP) of IKIP PGRI Pontianak for 2021 - 2025. One of the superior areas of RIP IKIP PGRI Pontianak for 2021 – 2025 is the Innovative Education and Learning Sector in the Fields of Mathematics and Natural Sciences, Technology, Social Affairs and Humanities with the superior topic of ICT-based learning whose focus is producing electronic learning modules from ICT-based learning models. Of course, research into Mobile Virtual Laboratory Innovation as an Informatics Learning Facility for High School Students in Pontianak City is felt to be very appropriate to this topic and in line with the plans that need to be carried out in producing ICT-based learning. Mobile Virtual Laboratory Innovation Research as an Informatics Learning Facility for High School Students in Pontianak City can encourage schools, especially high schools, to implement KM to prepare human resources who can adapt to the Industrial Revolution 4.0 and Society 5.0.

METHODS

The type of research used in this research is the research and development (R&D) method. R&D is a research method that uses various methods and research at each stage to carry out the process of developing educational tools (Ali & Asrori, 2014). Sugiyono revealed that R&D research not only aims to develop something but also discover and validate products (Sugiyono, 2017). Through this R&D research, the product that will be produced is the Mobile Virtual Laboratory (MVL) as an Informatics learning facility for high school students in Pontianak City. It is hoped that this MVL can help schools that have problems related to the lack or absence of computer laboratories used for Informatics learning activities as well as being a means of independent learning for students who do not have personal computers.

Research subjects are development subjects and testing subjects. The development subjects consist of experts in the field of virtual laboratories and experts in informatics subjects. The role of the expert in this research is to see the feasibility in terms of media and materials of the MVL being developed. Test subjects are subjects used to obtain data about user responses to the management information system being developed. The trials in this research consisted of trials for students at schools that had implemented KM and schools that had not implemented KM.

To obtain data for building a Mobile Virtual Laboratory as an Informatics learning facility for high school students in Pontianak City, data collection was carried out for the DDD-E process. The tools used to collect data are documentation and questionnaires. Documents related to Informatics material for high school students in research are used to prepare appropriate materials and practices for Informatics subjects based on Informatics books issued by the Ministry of Education, Culture, Research and Technology. Documents related to information system design consist of flowchart documents, screen design documents, and storyboard documents. Documents related to development consist of interface creation documents, database creation documents, and coding documents.

Type of questionnaire The type of questionnaire used is a closed questionnaire where respondents are given the opportunity to provide answers in the columns provided and are given a score. The grid used for media experts, material experts, and user responses is a development of the questionnaire used for developing learning media in previous research (Sabirin et al., 2022).

The design used to create the Mobile Virtual Laboratory (MVL) as an Informatics learning facility for high school students in Pontianak City is Decide, Design, Development and Evaluation (DDD-E) (Ivers & Barron, 2016). The description of each stage is as follows:

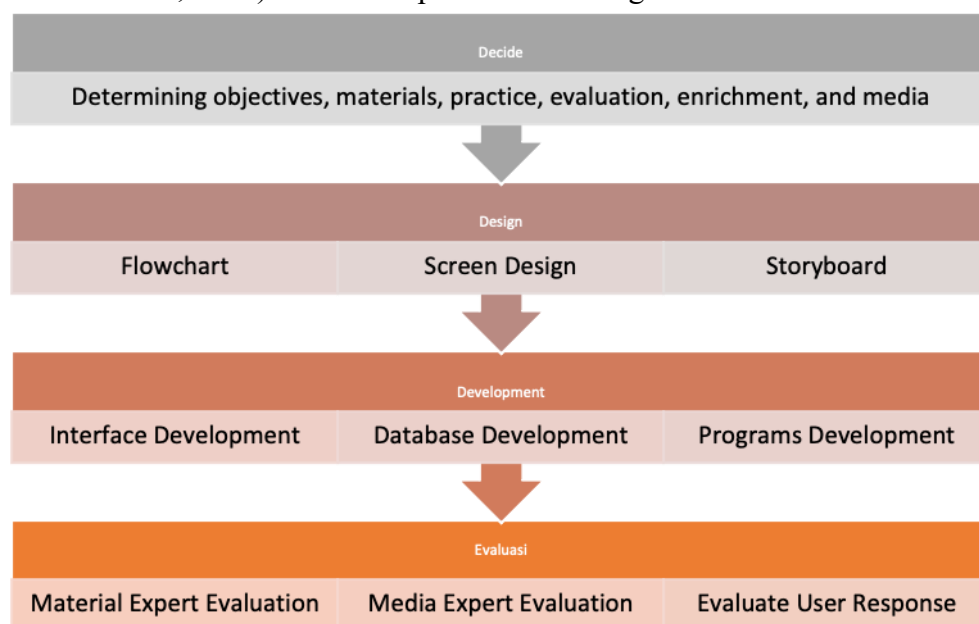


Fig 1. Research Procedure

The feasibility assessment in this study involves three main indicators, namely validation by material experts on suitability, quality of content and purpose, instructional quality, validation by media experts on ease of use and navigation, aesthetics, media integration, and technical quality, as well as user responses to determine ease of use and navigation, clarity of presentation, aesthetics, and technical quality. The indicators can be seen in table 1.

Table 1. Instrument Indicator

No	Penilaian	Aspek
1.	Material Expert	Suitability Quality of Content and Purpose Instruksional Quality

2.	Media Expert	Ease of Use and Navigation Aesthetic Media Integration Technical Quality
3.	User Response	Ease of Use and Navigation Clarity of Presentation Aesthetic Technical Quality

(Sison et al, 2024; Triatmaja et al, 2021; Alharbi, 2018)

The data analysis technique in research into the development of the Mobile Virtual Laboratory (MVL) as an Informatics learning facility for high school students in Pontianak City is a quantitative and qualitative data analysis technique. Qualitative data was obtained from the decide stage, design documents and development documents. Quantitative data was obtained from questionnaires from material experts, media experts, and user responses. The qualitative and quantitative data obtained in this research were analyzed descriptively.

RESULT AND DISCUSSION

RESULT

The results obtained from research on "Mobile Virtual Laboratory Innovation as an Informatics learning facility for high school students in Pontianak City" is an application in the form of a file with the .apk extension. The development of Android-based learning media goes through stages in the DDD-E model (Decide, Design, Development and Evaluation).

The decide stage is carried out to determine initial needs in developing learning media and is carried out to determine objectives, materials, practices, evaluation, training and media. The decide stage is carried out in the form of content and devices (hardware and software). Next, the design stage is designing a product that is developed based on the analysis and reference collection carried out. The result of the design stage is a flowchart. The following is the MVL media flowchart:

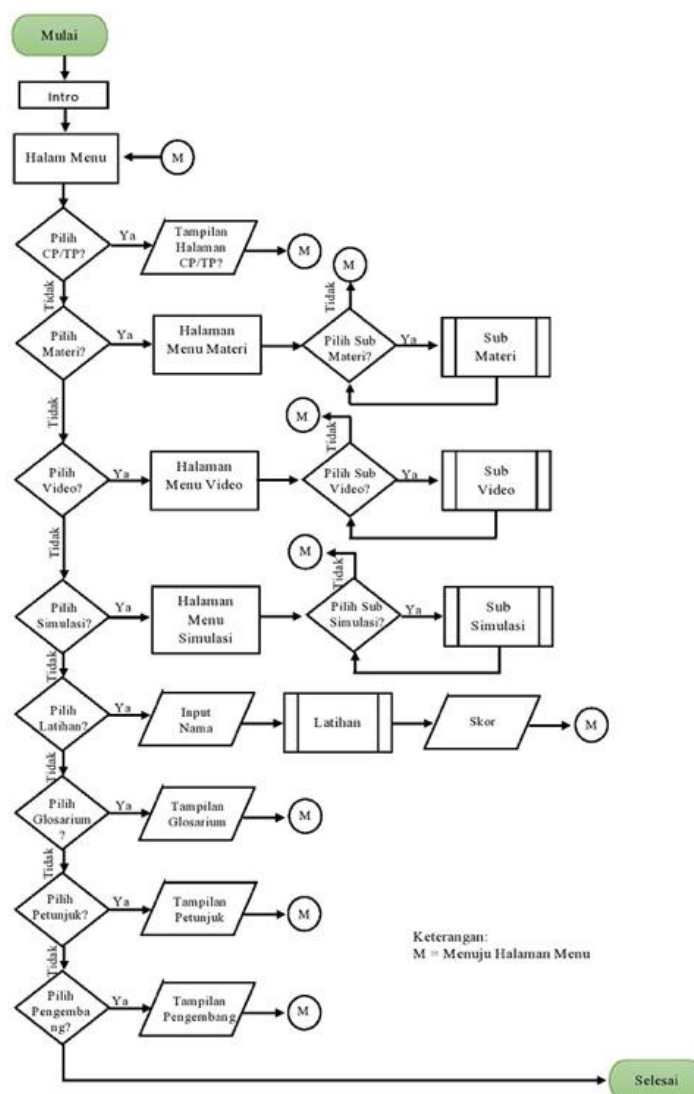


Fig 2. Flowchart

The explanation of the flowchart above is that starting from the first time the application is run, it will display an intro page. The intro page functions to display information on the learning media title, school logo, loading animation, loading description, school name, and initial information for using the application. After the intro page, the user will enter a menu page which functions to display information on learning media titles and there are eight buttons that can direct the user to the selected menu. When the user selects the CP/TP button, the learning media will display CP/TP for Office Application Integration material. To return to the menu page, users can press the back button on the Android smartphone. When the user selects the material button, the learning media will display a material menu which presents buttons from the Office Application Integration sub-material. To return to the menu page the user can press the back button. When the user selects the video button, the learning media will display a material menu that presents buttons from sub-videos. To return to the menu page the user can press the back button. When the user selects the simulation button, the learning media will display a simulation menu which presents buttons from sub-simulations. To return to the menu page the user can press the back button. When the user selects the glossary button, the learning media will display a glossary in the form of a

summary of Office Application Integration material. To return to the menu page, users can press the back button on the Android smartphone. When the user selects the instructions button, the learning media will display instructions in the form of application usage information. To return to the menu page, users can press the back button on the Android smartphone. When the user selects the developer button, the learning media will display the developer in the form of Android-based learning media developer data information on the Office Application Integration material. To return to the menu page, users can press the back button on the Android smartphone. When the user presses the back button on the smartphone, the application will close.

The development stage is developing and testing media based on the results of the designs that have been created. Following are the development results:



Fig 3. Menu Page

The main menu page is created as the main page in MVL media. On the menu page there are several menu options such as CP/TP, Materials, Videos, Simulations, Exercises, and Glossary. Students can use the material menu to view the material they want to study. And there is a simulation menu that students can use to give users real experience in practicing the material. There are three simulations provided, namely a simulation of making a report in graphic form, a simulation of making a dynamic invitation letter, and making a presentation in graphic form. The practice menu contains practice questions presented in the form of a maze game. Users can practice while playing, to work on practice questions the user must move the player towards the correct answer while avoiding enemies. The glossary page is a page that functions to display a summary of the material. The following displays the Exercises page and the glossary page:

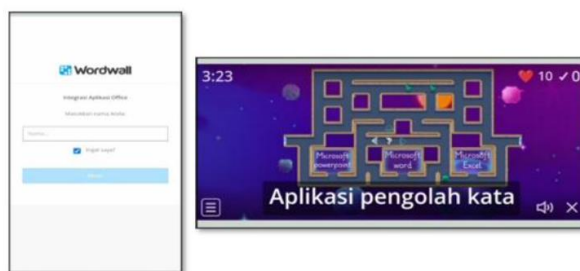


Fig 4. Practice Page



Fig 5. Glosarium Page

After it is developed, then an evaluation is carried out by material experts and media experts to see the feasibility of MVL. Material expert assessment is needed to assess the suitability of the material from the aspects of suitability, quality of content and objectives, and instructional quality. The following are the results of the scores obtained from the material expert assessment:

Table 2. Material Expert Assessment Results

No	Aspect	Mean	Categori
1.	Suitability	4,62	Very Good
2.	Quality of Content and Purpose	4,38	Very Good
3.	Instruksional Quality	4,57	Very Good
Mean		4,5	Very Good

Based on table 2, it is known that the average assessment of material experts on mobile virtual learning applications in informatics learning received a score of 4.5 or classified in the Very Good category. Next, a media expert assessment was carried out to assess Android-based learning media products in terms of ease of use and navigation, aesthetic aspects, media integration aspects, and technical quality aspects.

Table 3. Media Expert Assessment Results

No	Aspect	Mean	Categori
1.	Ease of Use and Navigation	4,8	Very Good
2.	Aesthetic	4,5	Very Good
3.	Media Integration	4,62	Very Good
4.	Technical Quality	4,37	Very Good
Mean		4,5	Very Good

Based on table 3, it is known that the average assessment of Android-based learning media experts on Office Application Integration Material received a score of 4.57 or classified as Very Good. Furthermore, an evaluation was carried out to see students' responses to Android-based

learning media in informatics learning. The following is data on the score obtained from student respondents' assessments:

Table 4. User Response Results

No	Aspect	Total Score	Freq.	Mean	Categori
1.	Ease of Use and Navigation	515	23	4,48	Very Good
2.	Clarity of Presentation	902	23	4,35	Very Good
3.	Aesthetic	512	23	4,45	Very Good
4.	Technical Quality	398	23	4,32	Very Good
Mean		101,17	23	4,40	Very Good

Based on table 4, it is known that the average score of Android-based learning student respondents in the informatics subject received a score of 4.40 or classified as very good.

DISCUSSION

Development of virtual laboratory innovation as an informatics learning facility for high school students in Pontianak City using the R&D (Research and Development) method by adapting the DDD-E (Decide, Design, Development - Evaluation) development model. The first stage in developing a virtual laboratory is the decide stage. The decide stage according to Roger S Pressman, (in Taupik, et al 2013:35) is to understand the system that identifies problems and finds solutions. The content presented in the virtual laboratory is based on the independent curriculum, especially for the Information and Communication Technology element which consists of office application integration and advanced features of office applications. The content of the virtual laboratory is arranged following the Independent Curriculum, focusing on the Information and Communication Technology element, especially the integration and advanced features of office applications. In accordance with Yanto et al. (2023), the use of virtual laboratories increases the ease and benefits of student learning, so that they are able to optimize the use of computers to face global challenges. The decide stage in this research consists of content, hardware and software. According to Mevlüt Ersoy et al. (2022), the compatibility between hardware and software greatly influences the success of virtual laboratory implementation, because good integration between the two ensures efficient experiments and optimal learning experiences. Based on the study, it is known that students in Pontianak city already have adequate smartphone devices, this is in line with a survey conducted by the government where smartphone penetration in the city reached 85%, which means that almost all high school students already have and are active in using smartphones (BPS, 2024).

The second stage is design which is the planning stage. The results of this stage are in the form of a flowchart and storyboard design. According to Mardi (2014: 21), a flowchart is a collection of symbolic diagram notations that show the flow of data and the sequence of operations in the system. Meanwhile, a storyboard is a sketch of images arranged sequentially according to a script. With a storyboard, you can convey story ideas to other people more easily, because they can lead someone's image to follow the images presented, thereby producing the same perception of the story idea that will be produced (Ridoi, 2018:89). In the research of Doni Tri Putra Yanto et al. (2022), the material in the virtual laboratory acts as a basis for students to understand the concept before doing the practicum. The material, together with videos, simulations, and exercises, allows students to learn the necessary theory and then apply it in virtual experiments, increasing the effectiveness of practicum learning. The material in the virtual laboratory studies the use of office applications, especially the integration between number processing and word processing applications

After the design stage, it continues with the development stage of Android-based learning media according to the design that has been created using Thunkable online software. Thunkable

excels in no-code mobile app development, allowing apps to be created with a drag-and-drop interface, access to device features such as notifications and location, third-party service integration, and direct publishing to platforms such as the Apple App Store and Google Play Store (source: thinkable.com). The learning media has ten pages, namely the intro page, menu page, CP/TP page, material menu page, video menu page, simulation page, practice page, glossary page, instructions page, and developer page. Development of learning media using existing components in thinkable accompanied by block code. The components used in learning media are labels, images, buttons, loading, columns and rows. Labels are used to display text on learning media according to the design that has been created. Image is used to display images such as background images, icon images, and button images. Buttons are used as actions that can be pressed by the user which consist of page movement actions, actions to check the input data, and actions to view simulation work instructions in the form of popups. Loading is used at the start of the application, waiting for five seconds for the action to go to the menu page. Columns and rows are used to arrange the display layout so that it is neatly arranged. Code blocks in learning media are used as logic so that learning media can run well. Code blocks in learning media are used to move to the selected menu, set the time on the loading page, view popups in the form of simulation work information, and display incorrect and correct messages in the form of popups.

After the virtual laboratory was successfully developed, the learning media was tested with material experts. Based on the results of the material expert assessment, it is known that the Android-based learning media developed has a feasibility score of 4.5 on a scale of 5 or is in the very feasible category. Android-based learning media received a very good category because the learning media is in accordance with learning outcomes and learning objectives, the quality of the content and objectives is appropriate, complete, appropriate to the student's situation, and the instructional quality of both tests and assessments is motivating and the media provides assistance and learning opportunities. The results of this study are in line with the findings of Samosa (2021) and Hasb Allah & Hewary (2023) which showed that smartphone-based virtual laboratories are effective in presenting materials and simulations, as well as increasing students' conceptual understanding and positive attitudes towards learning. Smartphone-based virtual laboratories are effective in presenting materials and simulations because they allow flexible access, interactive visualizations, and independent experiments that improve students' conceptual understanding, science skills, and engagement (Zhao, 2025; Leong et al., 2019).

Apart from material experts, this Android-based learning media was also tested on media experts. Based on the results of the media expert assessment, it is known that the Android-based learning media developed has a feasibility score of 4.6 on a scale of 5 or is in the very feasible category. Android-based learning media received a very good category because the learning media is easy to use, aesthetic or beautiful in appearance, neatness and graphical display of the interface, there is media integration in the application of a combination of multimedia elements (text, graphics, sound, animation/video), and technical quality on readability and handling of answers or feedback (Hapsari et al., 2024; Prasetyo et al., 2024).

The final stage in developing Android-based learning media is implementation. The implementation function according to Loviana, et al (2020:15) is to find out whether the media being developed is in accordance with what was planned and helps in the learning process. Based on the test results, it is known that overall the student response was very good to the Android-based learning media that had been developed. This can be seen from the average student response score of 4.40 on a scale of 5. The results of the assessment of Android-based learning media are the same as research conducted by Agustina Wulandari (2018) and Muhammad Aji Susilo (2019) where in these two studies, learning media Android-based is classified as very decent/very good. Android-based learning media received a very good category because the learning media is easy to use, clarity of presentation in terms of language, material, examples, videos and practice questions,

aesthetics or beauty in appearance, neatness and graphical display of the interface, instructional quality of the media providing assistance, learning opportunities and motivating students. Although this mobile virtual laboratory has received good reviews from experts and users, further development is needed. Especially to complement other materials in Informatics subjects. In addition, the study has not measured the impact of using MVL in learning. Therefore, further research is needed to measure the impact of using MVL on students' digital skills. According to several studies, MVL has been proven to improve the quality of student learning (Samosa, 2021; Ürek, 2024).

CONCLUSIONS

Development, and Evaluation) development model. The decide stage shows that students have never studied ICT/informatics subjects so they have difficulty following informatics subjects and are interested in using learning media. The design stage shows that the design consists of ten parts, namely intro, menu page, learning achievement/learning objective (CP/TP) page, material page, video page, simulation page, glossary page, practice page, instructions page, and developer page. The development stage uses the Thunkable, Google Sites, Bandicam, Ezgif, Photoshop CS6, Bandicam, Youtube, and Wordwall applications. The feasibility of the media based on material experts and media experts is in the very good category and is suitable for use. Student responses to the media that has been developed are very good for use.

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CONFLICTS OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. All co-authors have seen and agree with contents of the manuscript. We certify that the submission is origin work and is not under review at any other publication.

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