

Development of an Android-based virtual laboratory as a database learning media for vocational school

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ABSTRAK

Tujuan pengembangan dan penelitian ini adalah menghasilkan produk laboratorium virtual berbasis android sebagai media pembelajaran basis data kelas XI SMK dilengkapi buku petunjuk penggunaan "Vlab base" dan meningkatkan pemahaman serta hasil belajar siswa pada topik pengelolaan tabel pada basis data menggunakan Bahasa SQL. Prosedur pengembangannya menggunakan metode Research and Development (R&D) dan pendekatan pengembangan aplikasi model waterfall. Hasil validasi dari ahli media mencapai prosentase 92 (sangat layak), ahli desain 93 (sangat layak), dan ahli materi 94 (sangat layak). Uji kepraktisan mencapai prosentase 95 (sangat layak), kelompok kecil 90,67 (sangat layak), dan uji coba kelompok besar 93 (sangat layak) yang mempermudah siswa belajar dan praktikum mandiri memahami pengelolaan database berkategori sangat layak dan dapat digunakan guru dalam pembelajaran. Hasil pre dan post test siswa meningkatkan nilai hasil belajar siswa sebesar 100% berdasarkan kriteria efektivitas ketika digunakan dalam pembelajaran.

ABSTRACT

The goal of this research and development is to create an Android-based virtual laboratory product as a database learning medium for class XI Vocational School equipped with a manual for using "Vlab base" and to improve understanding and results of student learning in the topic of managing tables in databases using SQL language. The development procedure employed the research and development (R&D) method to create Android-based learning materials and the waterfall model application development approach. The validation results are 92% (very feasible) from the media experts, 93% (very decent) from the design experts, and 94% (very decent) from the material experts. The practicality test reaches 95% (very feasible), the small group reaches 90.67% (very feasible), and the large group trial obtains 93% (very feasible), making individual practice and learning simpler for pupils to understand database management that is categorized as very feasible and can be used by teachers in learning. Based on the criteria of effectiveness for learning, the results of the students' pre-test and post-test showed a 100% improvement in the value of student learning outcomes.



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INTRODUCTION

The learning process in Vocational High Schools in productive subjects is a comparison of 70% learning with practicum and 30% learning theory for achievement of students' skills needed to compete in the working world to work independently/self-employed and work in industry and the suitable world of work. National Education Standards per Government Regulation Number 19 of 2005 states that "Vocational Middle Education prioritizes the preparation of students for the world of work to develop a professional attitude". As the purpose of the learning direction of the Vocational Institute is to create quality labor who have professional skills that fulfill the needs of commercial life and who can increase their potential for the development and adaptation of science, technology, and art, vocational learning requires experience in this field, practicing specific skills related to the world of work (National Standards for Vocational Secondary Education, Minister of Education and Culture Regulation No. 34 of 2018).

Developments of digital technology and transformations in educational patterns have forced the development of educational media to become more diverse. Current technology represents a practical instrument in the educational process. The very broad development of ICT needs to be utilized as much as possible. Android-based educational media promises excellent capability in changing student learning methods to obtain data, familiarize data, and provide opportunities for educators to improve methods. OS Android is open source, so many programmers are competing to make Android-based learning media (Kocakoyun & Bicen, 2017).

A crucial part of understanding physics is doing practical work. Many physics simulations can be employed in the teaching process in this age of information and technology. This simulation is an Android software that can be readily accessed and downloaded for nothing from the Google Play Store. This chance can be used to enhance classroom instruction (Fikri et al., 2022), as well as developed a virtual laboratory based on the ACM-IEEE Computer Science Curriculum for several basic computer courses. The lab is a 3D virtual collaboration system with well-developed educational sequences that include teaching subjects. The 3D computing lab we created has two benefits. First, a composite component model was used to help pupils understand computing technology completely by combining difficulties seen from many angles. Second, educators can quickly identify the most challenging teaching ideas and change their approach by monitoring students' actions and progress (Branovic et al., 2013).

The virtual laboratory developed must be interactive, dynamic, lively, and fun and support the needs of students to learn and control practical topics using the SQL language for data processing. The virtual laboratory has a role in increasing the competence of knowledge, skills, and characteristics of SMK students. Laboratories for vocational students are vital to have a deeper understanding of learning material, especially productive subjects, because material without real practicum psychomotor abilities/skills is less than optimal in achieving learning objectives, and the learning process of vocational high school students is not enough to rely on learning theory and practice in the school's laboratory; students need to repeat learning and do the subject assignments at home. Less than 50% of students in class XI who have private practice devices have surveyed ownership of computer/notebook class XI RPL SMKN 2 Kraksaan practice devices. The surveys carried out by students, especially software engineering expertise competencies, require repeating material and practicums that have been carried out at school. If students do not have PC/Laptop devices at home, they cannot study practically at home and only rely on practicum facilities available at school, increasing student competency will be hampered. This is a development from previous research by Marlina (2019) that developed database modules that cover database concept topics, entity topics, and relationship diagram designs for associative learning, making it easier for users to carry out practical learning activities anywhere and anytime.

RPL skill competency students are guided and guided so they can apply themselves in software development, components for making desktop and Web-based software, including Databases for data processing on computer devices with SQL Language. SQL (Structured Query Language) is the syntax for processing databases. SQL data processing language plays an essential role in database software development design. SQL is implemented in applications as a link between software products and databases (Kadir, 2019). It is necessary for students of this

competency to understand and master SQL. The process of learning activities at school does not only provide cognitive information on the topic of Syntax SQL, database learning is packaged in mobile learning (Akdemir, 2016 ; Qian, 2017; Odabasi, 2019; Qun, 2021) , but students must also be able to implement SQL as data processing. The students in Software engineering expertise competency at SMKN 2 Kraksaan who carry out fieldwork practices in industry and the world of work and do not have independent practicum facilities at home in the form of computer/laptop devices can certainly not do practicum on database subjects and can only learn theory without practicum as one of the strategies to increase the competency skills of class XI students in software engineering expertise competency. This research developed a database subject practicum laboratory for class XI students in software engineering expertise competence virtually through an Android-based application that can be accessed from a smartphone that almost all students have. Therefore, it can help students carry out practicums without having to be in the laboratory room and a computer or laptop. Students can carry out practicum on database subjects at home without the need for a laboratory/PC/laptop. In particular, students undergoing practical fieldwork activities can carry out independent practicums freely without being limited by time and place and do not need to carry books and laptops anywhere. Based on the conditions in the description above, the research and development carried out is the creation of a virtual database laboratory using Android-based learning media for Class XI RPL SMK. The teaching and learning process can make use of a virtual laboratory anytime and anywhere as long as you have an Android device (Khairudin et al., 2019) . Mobile learning has a positive effect on student academic achievement in the Database Management System (DBMS) course (Gezgin, 2020) .

METHOD

This study employed the Research and Development (R&D) method with the waterfall approach. The waterfall is a type of SDLC (Systems Development Life Cycle) method model, System Development Life Cycle or System Life Cycle (Pressman, 2012; Alshamrani & Bahattab, 2015; Gupta, 2021; Khan, 2023; Agal & Soni, 2017) . The development model can resemble a waterfall where each stage of media development is carried out as a flow of water from top to bottom (Adrianto et al., 2017) . Figure 1 is a flowchart for developing an Android-based virtual laboratory using the waterfall method.

The five steps in the waterfall development model are as follows:

1. **Requirement Analysis**, where requirements are determined through analysis. In this step are two phases, namely:
 - a) Needs analysis to determine product results to develop Android-based educational content in the virtual database laboratory at SMKN 2 Kraksaan. The steps taken were a need assessment form of observations and interviews with the teacher supporting the database subject at SMKN 2 Kraksaan with the help of observations and interviews, identified products and material learning that fit their needs, learning objectives, and core competencies to find learning media products that suit students' needs.
 - b) Content analysis and technical specifications were made, which materials and devices were produced by Android-based Virtual Laboratories as learning media for *database practicum* based on basic competencies. Basic SQL implementation for managing database tables is as follows: (1) Understanding SQL commands for managing tables in databases; (2) Developing skills in using database client applications to execute SQL commands; and (3) Developing a critical, creative, appreciative, and original attitude in dealing with SQL commands to insert, call, update, and delete data through a database client application in a command line.
 - c) The software used by the researchers to create an Android-based virtual laboratory is Android Studio Version 4.1, Xampp 7.2, Visual Studio Code, and Canva Design Mockup.
2. **Design**, with three steps: (a) Selection of Media (media selection) where the learning media to use depends on the characteristics of the material and the needs of students; (b) Content design is the creation of material that is structured and inputted into an Android-based virtual lab, which includes core competencies basic competencies and the most crucial learning materials for the current semester of database subjects; (c) Designing the display of Android

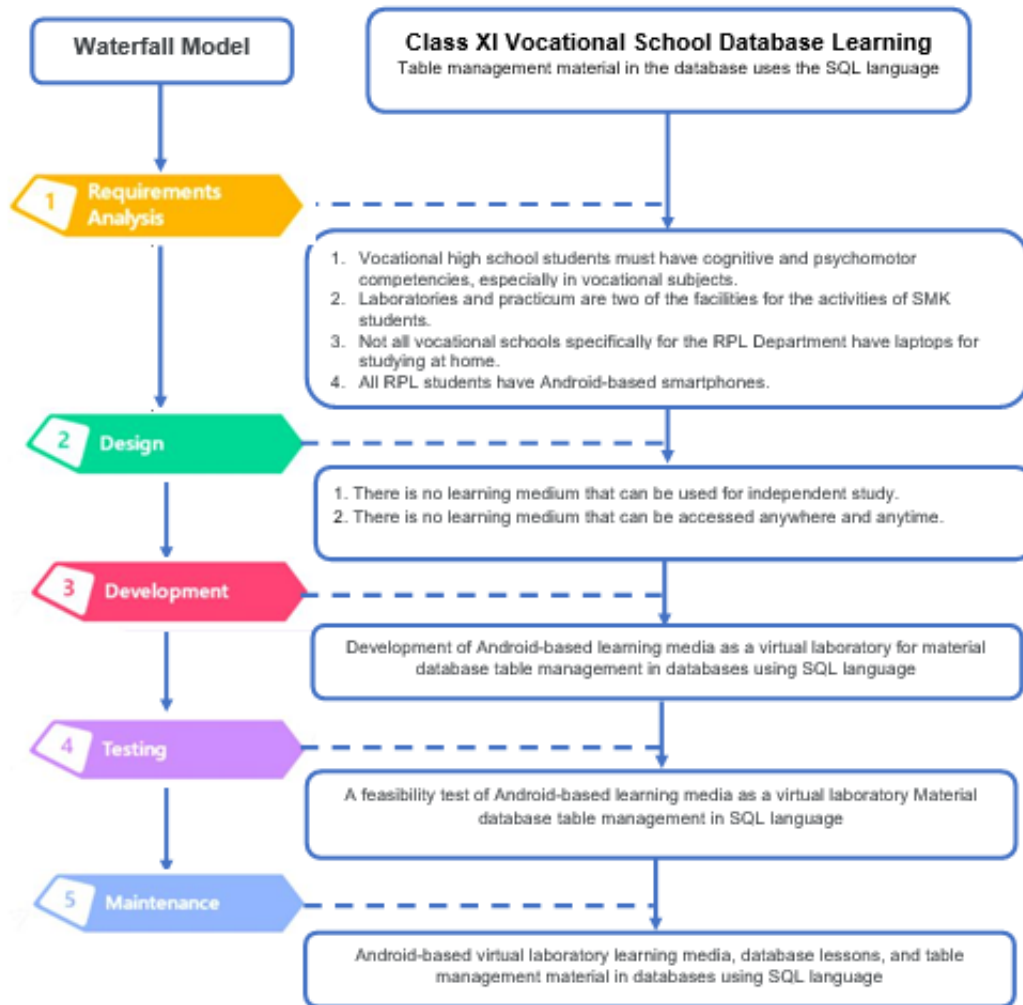


Figure 1. Database virtual laboratory development design

based learning media that consists of two steps: 1) Making flowcharts for students and web-based Vlab base application of administration menu accessed by teachers; 2) Creating a Virtual Laboratory Database Storyboard, namely Storyboards for Android-based students and Virtual Laboratory Application Administrator storyboards Web-based for teachers.

- 3. Development**, where Android-based virtual laboratory developers implement the previously designed application design into a program and then turn it into an Android-based application used in Database subjects. The coding uses the Java programming language, SQL lite, and PHP.
- 4. Testing**, refers to the stage of using the developed media prototype and soliciting responses from experts, practitioners, and students of class XI RPL SMK Negeri 2 Kraksaan. This product has undergone testing to determine the viability, usefulness, and appeal of the resulting learning media. The experts and practitioners involved in product trials were learning media experts, learning materials experts, and colleagues. The purpose of testing is to minimize errors and ensure that the resulting product is as desired. After being validated by experts, a limited field test was carried out to see the results of implementing an Android-based virtual lab in classroom learning, including measuring the students' feedback. The field trials in this activity were in groups of students, namely small groups with 15 students of class XI RPL 2 and large group trials with 36 participants of class XI RPL 1.
- 5. Maintenance**, which determines any problems with the product developed after the deployment phase. In this phase, it was to check for errors that were not detected previously.

Data analysis techniques in this study were in qualitative and quantitative descriptions. Quantitative data was obtained through validity measurement, practicality assessment by the

teacher, and questionnaire response by learners. The qualitative data were suggestions, comments, revisions, and the results of observations during the trial. In addition, the data that were originally in the form of scores were transformed into qualitative data using a *Likert* scale adopted from Sugiyono (2018). Likert scale used in media feasibility validation survey is with intervals 1-4. When collecting quantitative data, each alternative answer is recorded as in Table 1 and 2.

Table 1. Validity score on the Likert scale

Alternative Answers	Mark
Very suitable/Very good	4
Appropriate/Good	3
Good Enough/Good enough	2
Not suitable/Not good	1

Quantitative data analysis in this study calculated the percentage of answers to each question posed in the research questionnaire. Managing questionnaire data from distributing expert questionnaires validated and analyzed using Formula 1 adopted from Soviana (2018) .

$$P = \sum x / \sum xi \times 100\% \quad (1)$$

Information: P= percentage, $\sum x$ = total number of respondents' answers in one item, $\sum xi$ = the total ideal value in 1 item, and 100%= constant.

Table 2. Guidelines for interpreting the quality of learning media

Category	Percentage	Criteria	Information
4	85 – 100%	Very worth it	Implementation without revisions
3	75 – 85 %	Worthy	Implementation with few revisions
2	55 – 74%	Pretty decent	Revision according to the notes of experts and practitioners
1	>55%	Not worth it	Revision with changes

RESULTS

Development results of the Android-based educational content in the form of a virtual database laboratory using Android Studio developer applications, Visual Studio, Code, XAMPP, PHP, and SQL are as follows. We named this virtual laboratory media product the "Vlab Base" application. This application can be installed on students' smartphones with a minimum OS Android Lollipop (5.0), 3 GB RAM, and 32GB Minimum Storage. Students do not have to be connected to data packages continuously to use this application. The database virtual laboratory consists of two integrated applications and two platforms, namely Web-based Application Admin and Android-based Applications for students. The following is a more detailed explanation:

1. Administrator of the web-based Vlab Base application. This is accessed by database subject teachers of the SMKN 2 Kraksaan on <https://vlabbase.smkn2kraksaan.sch.id/>. They first enter student data according to the division of teaching tasks. To ensure that the students downloading the application are Class XI RPL SMKN 2 Kraksaan, there is a student account verification via e-mail when downloading the application, of which link and username will be sent to the e-mail of the registered student. The Vlab base application can be used for some materials that will be added by the Admin. In this case, teachers. In teaching database subjects, teachers can also obtain a recap of student activities results, including recapitulation of achievement in reading material, working on Quiz, doing practicum exercises up to evaluation of knowledge questions with automatic scores, and evaluation of SQL language practice by giving grades to see the results of practicum evaluations. The display of the opening page and home page of the virtual laboratory application admin is in Figure 2.

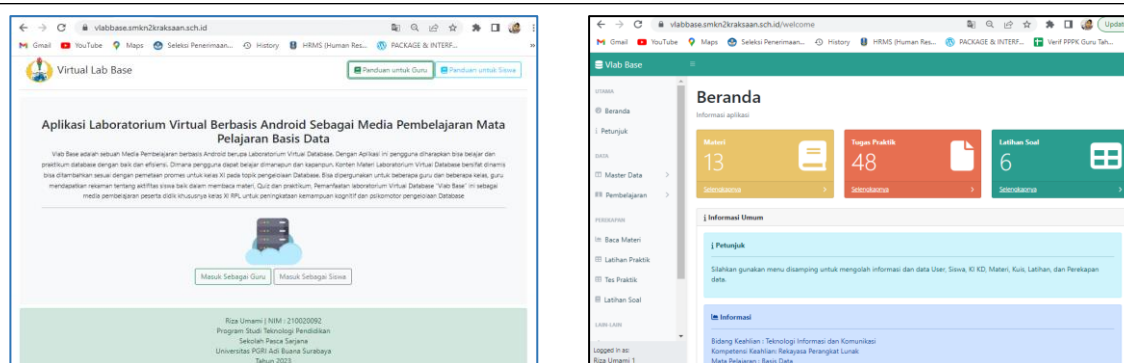


Figure 2. Appearance of the opening page and admin homepage of the vlab base application

- The Vlab base application for students can be downloaded at the web address that the teacher has provided, namely <https://vlabbase.smkn2kraksaan.sch.id/> by entering NISN (student number) to identify whether they belong to class XI RPL students of SMKN 2 Kraksaan or not. There is an email address and cellphone number for sending application download links and passwords. The content of the Vlab Base Application consists of (1) Material; (2) MIKARY Quiz (choosing Query words); (3) Practice Room for SQL Language practicum exercises; and (4) Evaluation that consists of practicum evaluation in the practice room and knowledge evaluation in the form of multiple choice questions. All Vlab Base Application content is dynamic but the scope of application is limited only to Database subjects. It is dynamic because the content can be added if there is additional material or Quiz from the teacher by selecting the material sync menu, Quiz and evaluation, and participant activities on the Vlab application base can be recapitulated by the teacher if the students carry out a synchronous upload of material achievements, quizzes, practicum, and evaluation. The data package is only used if it is synchronized to download material and upload the achievements of student activities. The display of the login page, opening/home page, synchronous page, and material page is in Figure 3.

The development of the Virtual Database Laboratory uses a triangulation validation technique, namely by involving one expert in content/materials, one in media, and one in design validation to assess the Virtual Laboratory Database that has been developed and provides suggestions for researchers for improvement.

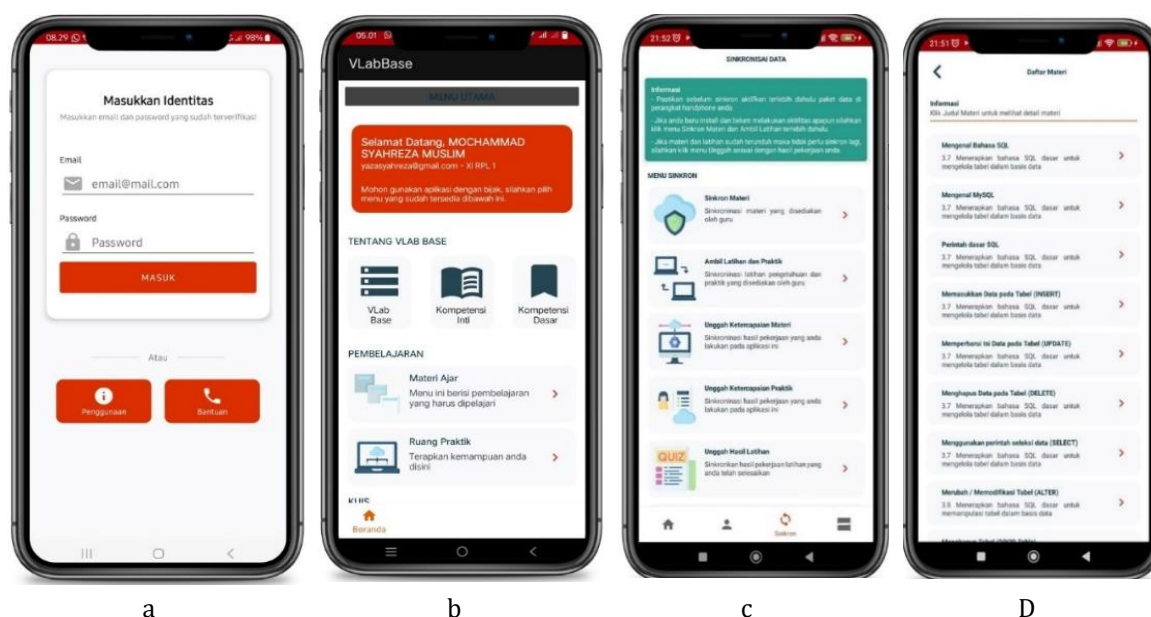


Figure 3. Display of the vlab base application page

Material Expert Validation

Informatics Engineering Lecturer at Nurul Jadid University Paiton, Probolinggo, has validated the validation of content/material expert laboratory virtual database. Material expert validation results through a questionnaire with five aspects consisting of 22 questions, with expert material validation shown in [Table 4](#).

Table 4. Result of Material expert validation

No	Rated aspect	Average/Maximum Score	P (%)	Criteria	Information
1	Material relevance	20/20	100%	Very worth it	Implementation without revisions
2	Material presentation	32/36	89%	Very worth it	Implementation without revisions
3	Appropriateness evaluation	12/12	100%	Very worth it	Implementation without revisions
4	language	11/12	92%	Very worth it	Implementation without revisions
5	Effects on learning strategies	11/12	92%	Very worth it	Implementation without revisions
Final average			94%		

Media Expert Validation

The class database virtual laboratory was validated by a lecturer at PGRI Adi Buana Surabaya University. The media expert validation used a questionnaire with five aspects of 23 questions. The findings of media expert validation are in [Table 5](#).

Table 5. Media expert validation results

No	Rated aspect	Average/Maximum Score	P (%)	Criteria	Information
1	Software engineering	26/28	93%	Very worth it	Implementation without revisions
2	Learning Design	15/20	75%	Worthy	Implementation with few revisions
3	Ease (maintainable)	16/16	100%	Very worth it	Implementation without revisions
4	Compatibility	11/12	92%	Very worth it	Implementation without revisions
5	Usability (functionality)	16/16	100%	Very worth it	Implementation without revisions
Final Average			92%		

Design Expert Validation

Table 6. Design expert validation results

No	Rated aspect	Average/ Maximum Score	P (%)	Criteria	Information
1	Appearance	19/20	95%	Very worth it	Implementation without revisions
2	Coloring	14/16	88%	Very worth it	Implementation without revisions
3	Image (photo)	15/16	94%	Very worth it	Implementation without revisions
4	Letters (fonts)	11/12	92%	Very worth it	Implementation without revisions
5	Menus (icons)	15/20	94%	Very worth it	Implementation without revisions
Final average			93%		

The design expert validation of the virtual database laboratory was validated by a lecturer at the Postgraduate School, Education Technology Study Program, PGRI Adi Buana University Surabaya. The design expert's validation results using a questionnaire with five aspects consisting of 20 questions. The design expert's validation results evaluation are in [Table 6](#).

Product Trials

Peer Review

After expert validation, a peer review is needed to see the practicality of virtual laboratory learning media products carried out with instruments from 4 aspects consisting of 25 questions. The practicality assessment's findings are in [Table 7](#).

Table 7. Practicality assessment results

No	Rated aspect	Average/ Maximum Score	P (%)	Criteria	Information
1	Education	19/20	95%	Very practical	Practical to use
2	Material Presentation	23/24	96%	Very practical	Practical to use
3	attractiveness	19/20	95%	Very practical	Practical to use
4	Practicality	19/20	95%	Very practical	Practical to use
5	effectiveness	19/20	95%	Very practical	Practical to use
Final average			95%		

Student Response Trial

Android-based educational content in the form of a virtual database laboratory "Vlab Base" for class XI RPL has been validated and revised resulting in responses from students who were divided into 2 trial groups, namely:

- 1) Small group of 15 class XI RPL 2 students using a questionnaire with 3 aspects consisting of 15 questions from the small group responses as in [Table 8](#).

Table 8. Small group response results

No	Rated aspect	Average/ Maximum Score	Percentage	Criteria
1	Ease of use and navigation	269/300	90%	Very good
2	Practicality	274/300	91%	Very good
3	attractiveness	273/300	91%	Very good
Overall Average			90.67%	

- 2) Large group test by 36 students of class XI RPL 1 using a questionnaire with 3 aspects consisting of 15 questions. The results of the large group responses are in [Table 9](#). From the results of the responses of students who have used the "Vlab Base" Virtual Laboratory as a learning medium, they get an overall average score of 93% above the 75% interval with very acceptable standards and is appropriate for usage as a database practicum learning media.

Table 9. Results of large group trials/responses

No	Rated aspect	Average/ Maximum Score	Percentage	Criteria
1	Ease of use and navigation	659/720	92%	Very good
2	Practicality	675/720	94%	Very good
3	attractiveness	675/720	94%	Very good
Overall Average			93%	

User Response Effectiveness Analysis

Response data is obtained by providing effective instruments to colleagues, namely software engineering subject teachers and student activities in the use of virtual laboratories, and student learning outcomes (knowledge evaluation and practical table management on databases) can be recapitulated by teachers through the Virtual Laboratory admin web page "Vlab Base". The results of the analysis of the effectiveness of the user's response are in [Table 10](#).

Table 10. Data from the recapitulation of the effectiveness of user responses

No	Data source	Percentage	Criteria
1	The Effectiveness Instrument for RPL teachers at SMKN 2 Kraksaan	95%	Very effective
2	Student activity	95%	Very effective
3	Student learning outcomes (knowledge and practicum evaluation results)	94%	Very effective
4	Ascension mark pretest and posttest	100%	Very effective
Average percentage 96 %			

The average result of the effectiveness of the user's response is 96 % with the "Very Effective" criteria. Moreover, after checking on the outcomes of the pre-and post-tests that were conducted by the student, there occurs enhancement by 100%. According to the results of user response recapitulation data through the effectiveness aspect, it can be concluded that the virtual laboratory database on table management material in the database is very effective and it gets a very positive response from users, so it can be used for learning, especially vocational subjects for class XI SMKN database.

DISCUSSION

According to data analysis findings supported by subject-matter specialists, the overall average percentage reached 94% if it is correlated with possible aspects of the product in Table 2. The developed "Vlab base" Database Virtual Laboratory has very feasible qualifications to be implemented without revision. Material experts also provide qualitative results of product development data (feedback/input data) virtual laboratory database class XI, namely application development. It would be nice if it could be used by several database subject teachers and added to the material database training video link to make it easier to understand database practicum in the application. This is in line with [Tagliacane et al. \(2016\)](#) who propose the creation of a virtual lab solution with three virtual routers and two virtual endpoints. The outcomes demonstrate accurate data demonstrating the effectiveness and dependability of the virtual simulation environment for teaching IT network topics in higher education, which overcomes some of the drawbacks of the existing GNS3 and Packet Tracer simulation software. In Health Education ([Herzog, 2015](#)) simulation through virtual laboratories is a valuable part of supporting knowledge transfer. Based on the defined knowledge profile for the eHealth course, a virtual laboratory should be developed.

The results of data analysis by design experts the overall average percentage reaches 93% if it is correlated with product feasibility in [Table 2](#). The developed "Vlab base" Database Virtual Laboratory has very feasible qualifications to be implemented without revision. Design experts also provide qualitative product development data results (data feedback/input) of Laboratory virtual database class XI; the password for the user and the evaluation recap are added. The Mobile learning design for high school and vocational schools gymnastic materials can be used as a support for distance learning as long as it demonstrates how mobile learning can be used as a convenient and helpful aid for remote learning, enabling the achievement of learning objectives ([Oktariyana, 2021](#)). In addition to developing The design of the mobile application devices, ReFlex and TeamUp were created especially for student centers and cooperative classroom instruction, where ongoing reflection is a critical component of the learning process ([Leinonen et al., 2014](#)).

Media expert validation results in Quantitative data, with the total average percentage as a whole reaching 92%, and the value predicate is very feasible without revision. Media experts also provide results of qualitative product development data (feedback/input data). Learning resources for Android is a class XI database virtual laboratory, namely Develop media equipped. [Gupta \(2019\)](#) states that traditional classroom teaching is being replaced by ultra-modern techniques, textbooks with e-books and online databases, student backpacks with smart electronic devices, and physical laboratories with virtual laboratories. E-learning has been introduced for faster and more comfortable learning and better understanding, it can be concluded that the actual laboratory can be replaced with a mobile/android-based virtual

laboratory. Sakya et al. (2022) stated that the rapid development of internet technology has prompted humanity to turn to virtual platforms, and this increasing popularity has paved the way for conventional teaching and learning processes. Therefore, it is now important to expand traditional practice labs to online platforms for the benefits of Android or smartphone-based learning media (Boutaba & Mitsuo, 2014; Ada, 2017 ; Al-adwan et al., 2018)

The outcomes of the colleagues' practicality validation test are an average percentage of 95% based on these results. So, we might say that the Virtual Database Laboratory is suitable to serve as a supporting medium of instruction Database learning. Teachers/colleagues as users of the Virtual Database Laboratory provide qualitative product development data results (feedback/input data), namely: (1) Android-based learning media content is by table management material in the database; (2) Learning media is designed very attractively and easy to use; and (3) students feel very happy and enthusiastic about learning databases using android-based learning media. This database virtual laboratory is in mobile learning that is very practical as a learning medium as Chen & Tsai (2021) state that Mobile technology presents possibilities for supporting learner-centered instruction. The findings give educators and teachers a thorough grasp of improved learning by state-of-the-art technology to design student-centered learning activities. Zhao et al. (2019) stated that students found the virtual tour very informative and useful, whereas the VR pump lab was intuitive and time-saving. This proves that with realistic lab simulations, virtual labs have great potential to give students more flexibility to carry out hands-on experiments and to develop technical acumen beyond the physical classroom. Teachers/instructors rushed to find new approaches to provide students with authentic laboratory experiences. Opportunities for the creation of fresh and engaging lab experiences are presented by the desire for innovative online teaching techniques and the growth of gamified training platforms. Online laboratories today provide a few aspects of the "real" lab experience. In virtual lab development, it costs little and is easy to download. Virtual laboratories used for undergraduate STEM education and real-world laboratory research are crucial. It also provides complete security from chemical, biological, and radiological threats and is more affordable than traditional labs.

The small group trials' outcomes led to an overall average of 90.67%, meeting the criteria of ease of use, comfort, and involvement of students in the learning process. Based on the small group trials, positive feedback was obtained, such as 1) in my opinion, the application is very good for female students as the application is easy to understand; and 2) it uses a background that is not boring, the writing is clear and easy to understand, and some suggestions as a reference for further revisions such as *when my cellphone is in dark mode, the color display on the Vlab Base application is buggy or the application does not support dark mode on Android* become a reference Vlab Base application improvements. Istiqomah et al. (2022) explained that for higher education institutions that cannot directly conduct practical practicums, virtual labs as a technology-based learning medium in chemistry practicums can be employed as a solution. To help students better grasp, the virtual lab accurately depicts the laboratory setting and practical processes. Gunawan et al. (2019) tested the effect of the guided inquiry model in a computerized lab on students' scientific method abilities.

The big group trial's outcomes yielded an overall average value of 93% of the small group trial results that met the criteria of being easy to use, practical, and attracting students' attention to the learning process. Among others: 1) On each page are clear instructions on how to operate the Application; 2) Practice guessing questions Query is easy to do and can be done many times to work on Quiz; 3) Display Application can be applied to smartphones that use dark mode. Findings from the pre-and post-test -subject tests in the database of 36 students increased their scores by up to 100%. From these findings, we can conclude that student's comprehension of the learning process has improved. There are various benefits from the development of the "Vlab base" database virtual laboratory application, including making it easier for students to learn processing tables on databases using SQL and learn independently on aspects of knowledge and skills through practicum in virtual laboratories. Students can work anywhere and anytime, which can increase student learning activities and outcomes in table management material in the database in terms of knowledge and skills through independent practicum. In addition, teachers

can monitor activities and recap student learning outcomes. Virtual laboratories have a positive impact on learning; virtual laboratories provide space for students to test, observe, and revise their understanding iteratively to increase their scientific literacy (Liu, 2022). This is also in line with Umamah et al. (2021) showing that a virtual laboratory is necessary to develop effectiveness and increase student skills in tertiary institutions.

CONCLUSION

From the results of data analysis and product studies resulting from the growth of Android-based educational materials in the type of a virtual laboratory "Vlab Base" for class XI RPL, it is very advantageous for learning database subjects, especially in practical management of tables in databases using SQL scripts/syntax. This *Vlab base* application file is not so big that it can be easily downloaded and installed on students' Android smartphones, at least the Android Lollipop operating system. To run this application, students do not always use data packages; data packages are only for downloading material, task instructions, and uploading the results of activities so that student activity records can be identified and assessed and the teacher can provide feedback on the student's activities. The *Vlab base* application is very practical and can be used by students wherever they are to continue to read material, work on quizzes, and carry out database practicums independently. The development of the "*Vlab Base*" Database Virtual Laboratory is still limited to class XI SMK. It can be used as a reference for learning media for the database practicum of class XII SMK. Development of Learning Media Virtual Laboratory "Vlab Base" Database Subjects currently can only be installed on Android OS cellphones/smartphones. For further development, as they can be installed on iOS OS cellphones/smartphones, they can be installed on all types of cellphone operating systems/Smartphones, so that users can learn anytime, anywhere from smartphones of all types of Android and iOS, as well as adding content in the form of animation and sound to increase student motivation and enthusiasm, more interactive and dynamic, effective, right on target when needed to achieve learning goals.

Author contributions

The authors made significant contributions to the study's conception and design. The authors was in charge of data analysis, interpretation, and discussion of results. The final manuscript was read and approved by the authors.

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Conflict of interest

The authors declare that there is no potential conflict of interest.

Data availability statement

All data are available from the authors.

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