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PAPER

Revolution in Engineering Education through Android-Based Learning Media for Mobile Learning: Practicality of Mobile Learning Media to Improve Electrical Measuring Skills in the Industrial Age 4.0

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ABSTRACT

This study examines the practicality of Android-based learning media in improving students' ability to use electrical measuring instruments in the Industrial Revolution 4.0 era. This study adopted a research and development (R&D) approach using the 4D model. The research process involved practical use tests conducted by lecturers and students using a questionnaire that evaluated convenience, time, and usability. The study's results revealed that learning Android-based media for mobile learning showed a level of practicality that deserved a thumbs up. Aspects of convenience, time, and use all reach a good level of practicality, so they fall into the 'practical' category. Based on research findings, using Android-based learning media for mobile learning provides significant benefits to learning through easy access to learning materials, better interactive and practical visualization, efficiency of learning time, and self-evaluation. The benefits received can be added to understanding the use of electrical measuring instruments. However, the Android-based learning media currently being developed has not been integrated with artificial intelligence (AI), so there are still great opportunities for further research into its integration with education.

KEYWORDS

learning media, mobile learning, engineering education, electrical measuring skill

1 INTRODUCTION

The Industrial Revolution 4.0 era brought about significant changes in education, including electrical engineering. With the advent of digital technology, particularly Android-based applications for mobile learning, there are immense opportunities to enhance the interactivity effectiveness [1] [2] [3], and efficiency of the learning

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process [4] [5]. However, it is crucial to evaluate further the practicality of utilizing digital learning media, particularly concerning developing skills in utilizing electrical measuring instruments among students [6]. Integrating digital technology into the learning process is a primary challenge for educators [7] [8], necessitating efforts to bridge the gap between science and technology and the electrical engineering education (EEE) curriculum [9], [10]. This is particularly important in subjects that form the fundamentals of electrical engineering competencies, such as measurement and instrumentation.

This course aims to impart knowledge on various measuring instruments, including ohmmeters, voltmeters, and ammeters. Additionally, it covers the working principles of these instruments, error theory, and the measurement of current, electrical energy, voltage, inductance, resistance, capacitance, frequency, and magnetic fields. Printed materials, such as textbooks, handouts, and modules, have been the preferred media used by teachers for this course. However, this approach may lead to a less efficient learning process, as many topics require visual support to transform abstract concepts into more tangible forms. Incorporating multimedia elements such as videos, images, simulations, and animations can enhance students' understanding by providing concrete visualization of the subject matter [11].

The density of material covered within the classroom setting often leads to an incomplete learning process due to time constraints. The delivery of educational materials primarily relies on in-person classroom sessions, resulting in delays or even the absence of materials if a scheduled meeting does not take place. However, in line with the principles of 21st-century learning, education should be accessible anywhere and anytime, without being restricted by time or distance [12] [13].

Integrating technology, particularly mobile learning, becomes imperative to address this issue. Android-based learning platforms offer the flexibility to access educational materials remotely, ensuring students can engage in learning activities conveniently. By utilizing mobile devices, students can access and interact with educational content beyond the confines of the physical classroom, enabling them to learn anytime, anywhere. This approach empowers students to take control of their learning, fostering a more self-directed and independent learning experience [14] [15]. Furthermore, the incorporation of multimedia elements in the mobile learning environment enhances engagement and comprehension, as students can benefit from interactive videos, visual aids, simulations, and animations [16] [17]. Using Android-based mobile learning not only addresses time and distance limitations but also promotes a more comprehensive and flexible learning experience. This shift towards anytime, anywhere learning aligns with the evolving needs and demands of 21st-century education, facilitating more effective knowledge acquisition and skill development [18]. Technology integration in learning necessitates thorough planning to ensure the learning process's effectiveness and efficiency, thereby enhancing graduates' competence. By strategically incorporating technologies, such as Android-based platforms, educators can optimize learning experiences and outcomes. Educators can foster more effective and efficient learning processes through meticulous research and the implementation of technology-enabled learning experiences, equipping graduates with the competencies required for success in their future endeavors.

Considering the phenomena described, there is an urgent need for innovative learning approaches in measurement and instrumentation courses. To overcome this, research initiatives focusing on developing Android-based learning media for implementing mobile learning are essential. The specific research title for this initiative is "Engineering Education Revolution through Android-Based Learning Media for Mobile Learning." The formulation of the problem that guides this research is "How are Android-based learning media for mobile learning designed, and how practical

are they in measurement and instrument courses?" This study aims to determine the design and practicality of Android-based learning media specifically designed for mobile learning in measurement and instrument courses, with the research target of electrical engineering students at the Faculty of Engineering, Padang State University.

2 LITERATURE REVIEW

Media refers to any means used to convey messages from a sender to a recipient. In education, learning media encompasses both hardware and software components. Hardware examples include tapes, projectors, and televisions [19]. On the other hand, software refers to program contents containing information, storytelling in films, and materials presented through charts, graphs, and diagrams [20] [21]. Several types of learning media exist, including audio media, video, animation, and more [22] [23] [24]. With the development of science and technology, the use of learning media in measurement and instrument courses must also be adapted to the development of science and technology.

When selecting suitable learning media, several key factors should be considered. First, the media must be visually clear and easily readable. Second, it should be attractive and captivating, capturing the reader's attention and stimulating their interest in the message [25]. Third, the media should be simple, requiring minimal preparation and installation. Fourth, the media should be useful in facilitating the achievement of learning objectives [26]. Fifth, it should be accurate, aligning with the user's characteristics, the subject matter, and the intended purpose [27]. Additionally, the learning medium should be legitimate, meaning that it is designed and used to promote effective learning; it should possess a well-structured format and seamlessly integrate with the material being conveyed [28]. Moreover, there are technical considerations to be considered when packaging learning content within the media. These include ensuring conformity with the intended objectives, employing clear and easily understandable sentences or dialogue, utilizing visually comprehensible elements such as images and captions, and organizing the material in a structured manner [29] [30]. By carefully considering these criteria and technical aspects, educators can select and design effective learning media that enhance the learning experience, promote comprehension, and facilitate achieving desired learning outcomes.

The rapid development of information technology includes the widespread use of Android smartphones [31]. In Indonesia, a significant percentage of internet users, specifically 98% of them, are students, and most of the internet access, around 89%, is done through smartphone applications. Surprisingly, in the context of measurement and instrument courses, Android smartphones have not been fully utilized as learning media, despite the many features they offer. These features include large storage capacity, adequate screen size, messaging capabilities, cameras, video playback, multimedia support, multi-touch functionality, multi-tasking capabilities, flash support, and much more [32] [33] [34]. Given Android smartphones' array of features, teachers can leverage these devices as a medium to effectively convey subject matter to their students. By integrating Android smartphones into their teaching approaches, the learning process can be significantly enhanced and more interesting. Teachers' creative use of technology plays a pivotal role in achieving this objective.

Mobile learning, also known as m-learning, refers to using handheld and mobile information technology (IT) devices, such as personal digital assistants (PDAs), mobile phones, and smartphones, as mediums for teaching and learning [35] [36] [37]. It offers the advantage of delivering learning experiences anytime and anywhere due

to the compact nature of these devices. In recent times, the global education sector has witnessed a surge in the adoption of mobile device-based learning, further catalyzed by the COVID-19 pandemic that prompted a shift towards online learning [38] [39]. M-learning has the advantage that the device is small, so learning can be done anywhere and anytime [40] [41]. The advantages possessed by this mobile device should be maximally utilized by lecturers in learning measurements and instruments to improve students' abilities in using electrical measuring instruments.

Various previous studies have been conducted regarding the use of Android applications, which can positively impact learning. Mobile learning applications can effectively increase student participation and involvement in the learning process [42]. By increasing motivation and interest in learning, mobile applications can provide a more interesting and interactive learning experience, thereby increasing student learning outcomes.

The development of Android applications for mathematics courses provides alternative solutions to overcome challenges in understanding mathematics material, especially for students who have difficulty with the material [43]. This application is a valuable tool in overcoming the constraints of limited study time in the classroom, as it allows students to access learning materials from anywhere and at any time. The flexibility of mobile learning empowers students to review and reinforce their education at their own pace, allowing them to understand complex concepts more effectively. Additionally, the app's adaptability ensures that students with diverse learning needs can benefit from a personalized learning experience.

To improve students' critical thinking skills, the application of Android applications in project-based learning has facilitated the development of their necessary thinking skills and problem-solving, primarily through projects that are contextually relevant to their subject matter [44]. Incorporating technology into the learning process encourages students to think critically, analyze information, and make decisions. This approach empowers students to develop their critical thinking skills, which are essential for their academic and professional growth in today's rapidly changing world.

However, these studies focus on increasing students' cognitive competence, so psychomotor aspects must be considered in developing Android-based learning media. The psychomotor section covers practical skills in using electrical measuring instruments, which are also truly relevant in electrical engineering education. By combining interactive and simulation elements in an Android-based application, students can be actively involved in practical exercises and experiments supporting their psychomotor skill development. Thus, a holistic learning approach that integrates cognitive and psychomotor aspects can be more effective in increasing students' understanding and mastery of concepts and practical skills in using electrical measuring instruments.

3 METHODOLOGY

3.1 Research methodology

The research aims to produce a product and test its practicality. In this study, the research approach used refers to a four-stage approach, namely define, design, develop, and disseminate (4D).

Fig. 1. Chart 4D model

3.2 Research procedure

The procedure followed for the development of Android-based learning media for measurement and instrument learning is illustrated in Figure 2.

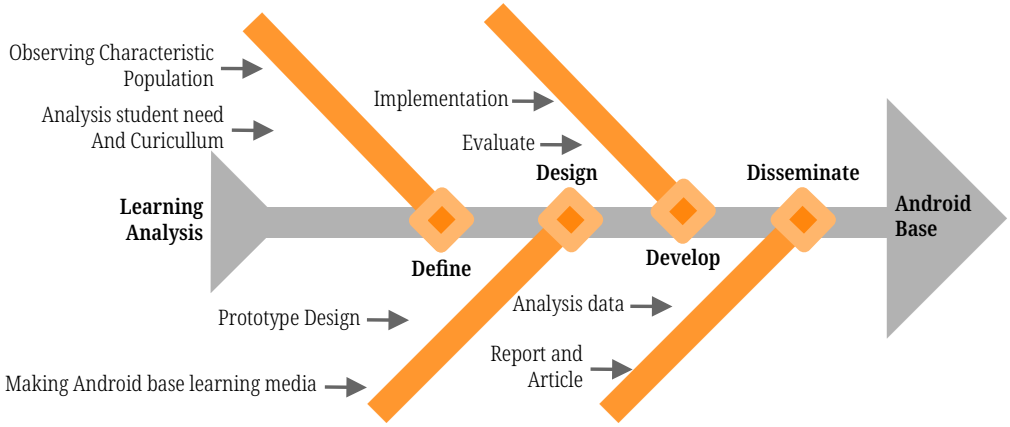

Fig. 2. Fish bone analysis of the research procedure

Define. During this stage, two key activities are conducted, namely observing and examining the characteristics of the research population. The observation activities aim to obtain an accurate understanding of real-life circumstances, while examining the population's characteristics which is essential for determining the research sample to be included in the study. These activities are crucial in providing clear guidance and establishing research boundaries, ensuring that the study is focused and pertinent to the defined objectives. By conducting thorough observations and examining the population's characteristics, the research can proceed with a well-informed approach that aligns with the intended goals.

Design. During this stage, two important steps are performed. The first step is to create a prototype of Android-based learning media for mobile learning with content tailored to the relevant syllabus. After the prototype design is complete, the next stage focuses on developing Android-based learning media for mobile learning. This phase entails creating actual learning materials and utilizing the finished prototype design as a foundation. By following these steps, the research ensures a systematic approach aligned with the targeted educational goals and syllabus requirements. At this stage, we also design a research instrument in the form of a questionnaire that will be used to measure the practicability of learning media.

Develop. During this stage, several important activities are carried out. First, the researcher implements Android-based learning media based on a previously designed framework. Furthermore, the researcher tested the Android-based learning media with a predetermined sample group of students. The aim is to collect data and feedback regarding the practicality of Android-based learning media in improving students' ability to use electrical measuring devices. This data and feedback will be used to evaluate the learning media developed and identify potential areas for improvement or refinement at a later stage. Through this development stage, researchers can produce relevant Android-based learning media, which improves the quality of learning and students' skills in using electrical measuring instruments.

Disseminate. During this stage, various activities are undertaken to effectively disseminate the research findings to relevant stakeholders. Firstly, the researchers collect data through questionnaires administered to the student sample group. The collected data is then subjected to descriptive analysis to gain meaningful insights.

Subsequently, the analysis results are interpreted and presented in a comprehensive research report. Additionally, the researchers prepare scientific articles to be published in reputable international journals. The main aim of this stage is to widely disseminate and share the research findings with the scientific community and practitioners in electrical engineering. Through these activities, the researchers aspire to contribute to and facilitate the advancement of electrical engineering education by promoting the effective and efficient utilization of Android-based learning media.

3.3 Sample

This study used a simple random sampling technique, in which the sample used was students of the electrical engineering study program, totaling 38 students taking measurement and instrumentation courses.

3.4 Research instrument

Practicality is obtained from the results of questionnaire data analysis with a Likert scale given to lecturers and students during the learning process using learning media. The first stage of the trial was carried out with small groups of 10 students. The first stage of the trial was carried out to find out how the responses, reactions, comments, and performance of the media developed if there were deficiencies. The technique used is direct observation. The second phase of the trial was done in a wider group, namely one class. The trial was conducted to determine the practicality of Android-based learning media by giving questionnaires to students and lecturers.

This practical questionnaire is used to measure how practical the learning medium has been. The practicality of Android-based learning media can be seen in its use by teachers and students. This practical instrument is explained using a Likert scale. To see the response of lecturers and students to the practicality of the developed media. The statement items on the questionnaire come from an extensive literature review and relevant research studies. Expert input was sought from educational technology, instrumentation, and measurement professionals to identify key factors. These key factors were then transformed into indicators and statements, as presented in Table 1. Before use, validity was tested using product-moment correlation to obtain a valid value (mean = 0.823, minimum = 0.524). In addition, Cronbach's alpha test confirmed the reliability of the questionnaire (alpha = 0.876) so that it can be declared valid and reliable for measuring the practicality of Android-based learning media for mobile learning.

Table 1. Practicality sheet grid

Assessment	Indicator	No. Item
1. Convenience	Operation	1, 2, 3, 4
	Retention of material	5, 6, 7
	Independence	8, 9, 10
2. Time	Preparation for use	11, 12, 13
	Use in learning	14, 15
3. Media usage	Ease of learning	16, 17, 18
	Interest in using media	19, 20, 21

The results of the practicality measurement were obtained through a questionnaire. The questionnaire consists of statements to determine the practicality of the

product. Alternative answers consist of strongly agree, agree, moderately disagree, and strongly disagree. The practicality of interactive learning media is as follows:

1. Score answers with the following criteria: 5 = Strongly Agree, 4 = Agree, 3 = Enough, 2 = Disagree, and 1 = Strongly Disagree.
2. Determine the average score obtained by adding up the values obtained from many indicators.
3. The value of practicality with the formula:

$$NA = \frac{S}{M} \times 100\%$$

Information:
NA = Final score
S = Score obtained
M = Maximum score

Based on the results of the practicality values obtained [45], they were then categorized according to the level of practicality as shown in Table 2.

Table 2. Media practicality categories

No	Achievement Rate (%)	Category
1	85–100	Very practical
2	75–84	Practical
3	60–74	Practical enough
4	55–59	Less practical
5	0–54	Not practical

4 RESULT AND DISCUSSION

4.1 Design result

Based on the observation results, data were obtained in the measurement and instrument courses of the Electrical Engineering Education Study Program, Faculty of Engineering, Padang State University, indicating that students have the personal ability to operate Android smartphones. Students are also familiar with the use of technological devices; without assistance, students can learn independently so that the application of mobile learning can be applied. Based on the results of these student characteristics, we can provide an overview of the media design and content that will be developed. Thus, the product is developed according to the student's character so that it can facilitate students, such as being easy to understand, material that follows the curriculum, and questions that stimulate students to explore their potential. It is also used as a basis for developing students' abilities. The following are the results of the development of Android-based learning media.

Welcome page. The welcome page features the primary title of the learning material, "Measurements and Instruments," in Indonesian, along with corresponding icons representing each sub-material included in this educational medium. The page includes two distinct buttons: the 'continue' button, which directs users to the Main Page for selecting their desired learning materials, and the 'exit' button, allowing users to close the learning media interface.

Fig. 3. Welcome page

Home page. The home page presents lecture material choices so students can choose according to the material they want to study, following their scientific conditions. Each material selection button has an icon that represents the material to be studied in that sub-material; this button will navigate according to the selected sub-material, and on this page, there is also an evaluation menu that will navigate to the evaluation page.

Fig. 4. Home page

Material page. The material page displays learning material presented with text accompanied by an explanatory video by the lecturer and a video accompanied by animation that can attract students' attention and break down abstract learning

material into more concrete. Students can play videos repeatedly according to each student's learning speed so that they can understand the material more optimally.

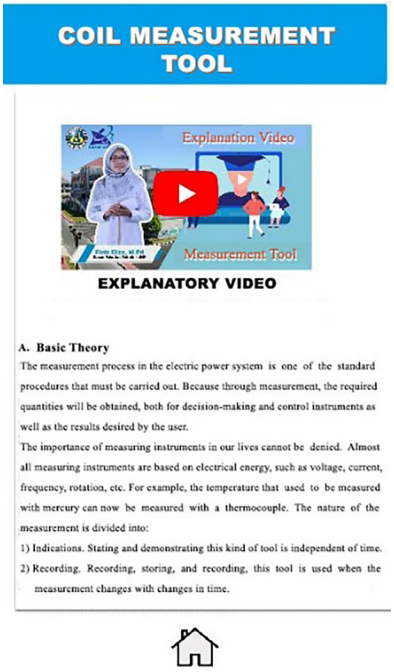

Fig. 5. Material page

The evaluation page. The evaluation page is meant for students to test their abilities. On this page, students will work on 30 multiple-choice questions, which will be given randomly so that each student gets a different question. After working on all the questions, the scores obtained by students will be displayed in real-time, so students can find out how well they understand the concept of instruments and measurements.

Fig. 6. Evaluation page

This development stage aims to test the practicality of the product that has been made. In testing the practicality of Android-based learning media, this study involved two groups of subjects, namely lecturers and students. The practicality testing phase is done using a questionnaire describing aspects of practicality, time aspects, and aspects of learning media use. Respondents were asked to provide ratings and responses regarding the ease of use of the media, the effectiveness of saving time, and the usefulness of using the media in increasing their understanding of using electrical measuring instruments. Rating scales were used to rate each aspect, with rating options ranging from "Very Good," "Good," "Fair," "Poor," and "Very Poor." The collected data was then analyzed statistically and descriptively to determine the practicality of Android-based learning media.

To find out the practicality of Android-based learning media in measurement and instrument courses, a practical questionnaire was conducted with 38 students to provide an overview of their experiences using Android-based learning media. The questionnaire aims to collect valuable information about their experiences using Android-based learning media during the learning process. The results of students filling out the practicality questionnaire can be seen in Table 3 below.

Table 3. Practicality data from students response questionnaire

Assessment	Indicator	Score	Categories
1. Convenience	Operation	82.7	Practical
	Retention of material	78.2	Practical
	Independence	80.6	Practical
2. Time	Preparation for use	74.4	Practical Enough
	Use in learning	80.0	Practical
3. Media usage	Ease of learning	85.4	Very Practical
	Interest in using media	83.2	Practical
Average Response		79.3	Practical

In addition to students, a practicality questionnaire was also given to two lecturers from the department of measurement and instrument to provide an overview of their experiences while teaching with the help of Android-based learning media in measurement and instrument courses. The results of filling out the practicality questionnaire by the lecturers can be seen in Table 4 below.

Table 4. Practicality data from lecturer response questionnaire

Assessment	Indicator	Score	Categories
1. Convenience	Operation	80.4	Practical
	Retention of material	82.5	Practical
	Independence	79.4	Practical
2. Time	Preparation for use	77.8	Practical
	Use in learning	82.3	Practical
3. Media usage	Ease of learning	80.8	Practical
	Interest in using media	81.5	Practical
Average Response		80.7	Practical

Based on Table 3, the practical results of Android-based learning media by students are 79.3 in the 'practical' category, and Table 4 shows the practical results at 80.7 in the 'practical' category. By collecting input from many students and teaching lecturers, a more accurate and representative understanding of the practicality of Android-based learning media is obtained. This shows that Android-based learning media can practically support the learning process and improve students' ability to use electrical measuring instruments.

4.2 Discussion

The findings of this study indicate that Android-based learning media developed for mobile learning in measurement and instrumentation courses have proven practical in increasing students' skills in using electrical measuring instruments. Videos, images, simulations, and interactive animations presented in learning media have provided a more interesting and immersive learning experience for students. Accessing educational content remotely has allowed students to review and reinforce their learning beyond the confines of the traditional classroom setting, encouraging independent learning. The positive results observed in this study underscore the importance of leveraging technology to optimize the learning process and equip students with competencies relevant to the modern industrial landscape. As technology advances, further research and development in mobile learning could lead to more impactful and transformative educational experiences for students in electrical engineering and other disciplines.

The research that has been carried out is in line with previous similar research [46], which uses Android-based learning media to enhance learning and focuses on chemistry students to increase their understanding of the concept of redox reactions with a sample of 20 students in a chemistry study program. The results show that Android-based learning media can be used as a source of mobile learning for studying the specific redox concepts of reduction and oxidation reactions. Other similar studies [47] focused on improving and understanding Japanese at the beginner level with a sample of 67 students, where an increase in student achievement was found after the use of Android-based media in supporting the learning process. However, both studies only focus on cognitive aspects. Meanwhile, the focus of this research specifically targets the field of electrical engineering and the use of Android-based learning media for measurement and instrument courses, where the emphasis is on psychomotor aspects of the ability to use electrical measuring instruments. The alignment of previous research with this research lies in the results of Android-based learning media that can be used to improve students' abilities in the learning process.

The advantage of this study is the significant difference in the number of samples. The sample of this study is large, namely 38 students and two lecturers, which provides better statistical power for generalizing research findings. By involving a larger sample size, this research can provide a better representation of the population and provide a more comprehensive understanding of the practicality of Android-based learning media for mobile learning in improving students' skills in using electrical measuring devices.

In future research, expanding the number of samples can be an important consideration to strengthen research findings and provide a stronger basis for recommending the use of Android-based learning media in electrical engineering learning.

By involving more participants, research can provide broader information about the practicality of these media and enrich our understanding of the use of technology in education. Research can be directed at integrating artificial intelligence technology into Android-based learning media. In addition, the development of AI technology opens opportunities for developing this research in the future to integrate AI into Android-based learning media for mobile learning that can provide adaptive and personalized feedback to students and be able to analyze and evaluate their learning progress automatically.

5 CONCLUSION

In this study, Android-based learning materials were created for mobile learning in measurement and instrumentation courses. Subsequently, the developed materials underwent a practicality assessment by both students and their accompanying lecturers. The contribution of this research lies in the successful development and practical implementation of Android-based learning media for mobile learning in measurement and instrumentation courses for electrical engineering students. By providing a learning platform in the form of learning media based on Android for mobile learning that is user-friendly and easily accessible, this research contributes to the advancement of electrical engineering education, especially in measurement and instrument subjects. Integrating multimedia elements into learning media fosters a more interesting and interactive learning experience and encourages deeper understanding and retention of knowledge among students. The confirmation of the practicality of Android-based learning media by students and supporting lecturers underscores its potential as a valuable tool for enhancing electrical engineering education. In addition, this research shows the importance of considering mobile learning as an alternative approach to traditional classroom teaching. Embracing mobile learning opens opportunities to study anytime, anywhere, allowing students to learn at their own pace and convenience. The positive results observed in this study can serve as a foundation for educational institutions and educators to explore and adopt innovative learning technologies, improving overall learning outcomes and student experiences.

6 REFERENCES

[1] A. Astalini, D. Darmaji, W. Kurniawan, K. Anwar, and D. A. Kurniawan, "Effectiveness of using e-module and e-assessment," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 9, pp. 21–39, 2019. https://doi.org/10.3991/ijim.v13i09.11016

[2] N. Fitriyana, A. Wiyarsi, J. Ikhsan, and K. H. Sugiyarto, "Android-based-game and blended learning in chemistry: Effect on students' self-efficacy and achievement," *Cakrawala Pendidik.*, vol. 39, no. 3, pp. 507–521, 2020. https://doi.org/10.21831/cp.v39i3.28335

[3] P. Widodo, M. Subandowo, L. Musyarofah, J. Slamet, and D. Ming, "Interactive gamification-flipbook for developing students' outcomes," *Adv. Mob. Learn. Educ. Res.*, vol. 3, no. 2, pp. 754–762, 2023. https://doi.org/10.25082/AMLER.2023.02.002

[4] P. Hendikawati, M. Z. Zahid, and R. Arifudin, "Android-based Computer Assisted Instruction development as a learning resource for supporting self-regulated learning," *Int. J. Instr.*, vol. 12, no. 3, pp. 389–404, 2019. https://doi.org/10.29333/iji.2019.12324a

[5] A. Xezonaki, "The use of Kahoot in preschool mathematics education," *Adv. Mob. Learn. Educ. Res.*, vol. 3, no. 1, pp. 648–657, 2023. https://doi.org/10.25082/AMLER.2023.01.014

[6] F. Shahnia and H. H. Yengejeh, "Various interactive and self-learning focused tutorial activities in the power electronic course," *IEEE Trans. Educ.,* vol. 62, no. 4, pp. 246–255, 2019. https://doi.org/10.1109/TE.2019.2892672

[7] I. Widiaty, Ana, L. S. Riza, A. G. Abdullah, and S. R. Mubaroq, "Multiplatform application technology—based heutagogy on learning batik: A curriculum development framework," *Indones. J. Sci. Technol.*, vol. 5, no. 1, pp. 45–61, 2020. https://doi.org/10.17509/ijost.v5i1.18754

[8] B. E. Dasilva et al., "Development of android-based Interactive Physics Mobile Learning Media (IPMLM) with scaffolding learning approach to improve HOTS of high school students," *J. Educ. Gift. Young Sci.*, vol. 7, no. 3, pp. 659–681, 2019. https://doi.org/10.17478/jegys.610377

[9] J. Qadir and A. Al-Fuqaha, "A student primer on how to thrive in engineering education during and beyond COVID-19," *Educ. Sci.*, vol. 10, no. 9, pp. 1–22, 2020. https://doi.org/10.3390/educsci10090236

[10] I. Ismail, M. M. A. Zabidi, N. Paraman, K. Mohd-Yusof, and N. F. A. Rahman, "Active and project-based learning implementation in a constructively aligned digital systems design course," *IEEE Trans. Educ.*, 2023. https://doi.org/10.1109/TE.2023.3280444

[11] M. G. Retuerto and L. Andrade-Arenas, "Prototype of a mobile application for teaching the first-grade letter course," *Adv. Mob. Learn. Educ. Res.*, vol. 3, no. 2, pp. 763–769, 2023. https://doi.org/10.25082/AMLER.2023.02.003

[12] S. Kim, M. Raza, and E. Seidman, "Improving 21st-century teaching skills: The key to effective 21st-century learners," vol. 14, no. 1, pp. 99–117, 2019. https://doi.org/10.1177/1745499919829214

[13] H. Almazroa and W. Alotaibi, "Teaching 21st century skills: Understanding the depth and width of the challenges to shape proactive teacher education programmes," *Sustain.*, vol. 15, no. 9, p. 7365, 2023. https://doi.org/10.3390/su15097365

[14] C. Maynard, J. Garcia, A. Lucietto, W. Hutzel, and B. A. Newell, "Experiential learning in the energy based classroom," *Int. J. Eng. Ped.*, vol. 11, no. 6, pp. 4–26, 2021. https://doi.org/10.3991/ijep.v11i6.16539

[15] H. S. Othman, S. B. Zaibon, and A. H. Z. Abidin, "The significance of edutainment concept in video-based learning in proposing the elements of educational music video for children's learning," *Int. J. Interact. Mob. Technol.*, vol. 16, no. 05, pp. 91–106, 2022. https://doi.org/10.3991/ijim.v16i05.23711

[16] Sujarwo et al., "Android-based interactive media to raise student learning outcomes in social science," *Int. J. Interact. Mob. Technol.*, vol. 16, no. 07, pp. 4–21, 2022. https://doi.org/10.3991/ijim.v16i07.25739

[17] D. T. P. Yanto, Sukardi, M. Kabatiah, H. Zaswita, and O. Candra, "Analysis of factors affecting vocational students' intentions to use a virtual laboratory based on the technology acceptance model," *Int. J. Interact. Mob. Technol.*, vol. 17, no. 12, pp. 94–111, 2023. https://doi.org/10.3991/ijim.v17i12.38627

[18] S. M. Leksono, P. Marianingsih, E. N. Ilman, and N. Maryani, "Online learning media on biology conservation: Rawa danau nature reserve website," *Int. J. Interact. Mob. Technol.*, vol. 15, no. 08, pp. 87–100, 2021. https://doi.org/10.3991/ijim.v15i08.21567

[19] H. H. Batubara, M. S. Sumantri, and A. Marini, "Developing an android-based e-textbook to improve learning media course outcomes," *Int. J. Interact. Mob. Technol.*, vol. 16, no. 17, pp. 4–19, 2022. https://doi.org/10.3991/ijim.v16i17.33137

[20] H. F. El-Sofany and N. El-Haggar, "The effectiveness of using mobile learning techniques to improve learning outcomes in higher education," *Int. J. Interact. Mob. Technol.*, vol. 14, no. 08, pp. 4–18, 2020. https://doi.org/10.3991/ijim.v14i08.13125

[21] S. Papadakis, "Apps to promote computational thinking and coding skills to young age children: A pedagogical challenge for the 21st century learners," *Educ. Process Int. J.*, vol. 11, no. 1, pp. 7–13, 2022. https://doi.org/10.22521/edupij.2022.111.1

[22] A. Huda, N. Azhar, Almasri, K. Anshari, and S. Hartanto, "Practicality and effectiveness test of graphic design learning media based on android," *Int. J. Interact. Mob. Technol.*, vol. 14, no. 4, pp. 192–203, 2020. https://doi.org/10.3991/ijim.v14i04.12737

[23] E. Yazıcı Arıcı, H. K. Keskin, S. Papadakis, and M. Kalogiannakis, "Evaluation of children's discourses regarding imaginary companion: The case of Türkiye," *Sustain.*, vol. 14, no. 24, p. 16608, 2022. https://doi.org/10.3390/su142416608

[24] A.-I. Zourmpakis, M. Kalogiannakis, and S. Papadakis, "A review of the literature for designing and developing a framework for adaptive gamification in physics education," *Int. Handb. Phys. Educ. Res. Teach. Phys.*, pp. 1–26, 2023. https://doi.org/10.1063/9780735425712_005

[25] Darmaji, D. A. Kurniawan, Astalini, A. Lumbantoruan, and S. C. Samosir, "Mobile learning in higher education for the industrial revolution 4.0: Perception and response of physics practicum," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 9, pp. 4–20, 2019. https://doi.org/10.3991/ijim.v13i09.10948

[26] D. Gormaz-Lobos, C. Galarce-Miranda, S. Kersten, and H. Hortsch, "Attitudes and perceptions of teaching staff about the online learning during the COVID19 pandemic: A case study of engineering education," *Int. J. Eng. Ped.*, vol. 12, no. 3, pp. 38–49, 2022. https://doi.org/10.3991/ijep.v12i3.29947

[27] D. F. Al Husaeni and A. B. D. Nandiyanto, "Bibliometric using vosviewer with publish or perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post Covid-19 pandemic," *ASEAN J. Sci. Eng.*, vol. 2, no. 1, pp. 19–46, 2022. https://doi.org/10.17509/ajse.v2i1.37368

[28] G. Liu, "Research on the relationship between students' learning adaptability and learning satisfaction under the mobile media environment," *Int. J. Emerg. Technol. Learn.*, vol. 17, no. 02, pp. 43–58, 2022. https://doi.org/10.3991/ijet.v17i02.28549

[29] L. A. Wardana, A. Rulyansah, A. Izzuddin, and R. Nuriyanti, "Integration of digital and non-digital learning media to advance life skills of elementary education students post pandemic Covid-19," *Pegem Egit. ve Ogr. Derg.*, vol. 13, no. 1, pp. 211–222, 2022. https://doi.org/10.47750/pegegog.13.01.23

[30] D. Saripudin, W. I. Fauzi, and E. Nugraha, "The development of interactive E-book of local history for senior high school in improving local wisdom and digital literacy," *Eur. J. Educ. Res.*, vol. 11, no. 1, pp. 17–31, 2022. https://doi.org/10.12973/eu-jer.11.1.17

[31] J. P. P. Miranda, "Development of INSVAGRAM: An english subject-verb agreement mobile learning application," *Int. J. Emerg. Technol. Learn.*, vol. 16, no. 19, pp. 219–234, 2021. https://doi.org/10.3991/ijet.v16i19.24071

[32] S. Papadakis, A. I. Zourmpakis, and M. Kalogiannakis, "Analyzing the impact of a gamification approach on primary students' motivation and learning in science education," *Lect. Notes Networks Syst.*, vol. 633, pp. 701–711, 2023. https://doi.org/10.1007/978-3-031-26876-2_66

[33] H. V. Saphira, B. K. Prahani, B. Jatmiko, and T. Amelia, "The emerging of digital revolution: A literature review study of mobile and Android based e-pocket book in physics learning," *Advances in Mobile Learning Educational Research*, vol. 3, no. 1, pp. 718–726, 2023. https://doi.org/10.25082/AMLER.2023.01.020

[34] D. M. Sutrisni, S. Utaminingsih, M. Murtono, I. O. Mariam, and H. Pratama, "The effectiveness of android-based budiran game assisted by smart apps creator 3 to improve science learning outcomes of fourth graders in theme 1," *Advances in Mobile Learning Educational Research*, vol. 2, no. 2, pp. 483–492, 2022. https://doi.org/10.25082/AMLER.2022.02.017

[35] A. Verawati, D. Agustito, W. Pusporini, W. Utami, and S. Widodo. "Designing Android learning media to improve problem-solving skills of ratio," *Advances in Mobile Learning Educational Research*, vol. 2, no. 1, pp. 216–224, 2022. https://doi.org/10.25082/AMLER.2022.01.005

[36] S. Papadakis, F. Alexandraki, and N. Zaranis, "Mobile device use among preschool-aged children in Greece," *Educ. Inf. Technol.*, vol. 27, no. 2, pp. 2717–2750, 2022. https://doi.org/10.1007/s10639-021-10718-6

[37] I. Haerazi, M. P. Utama, and H. Hidayatullah, "Mobile applications to improve English writing skills viewed from critical thinking ability for pre-service teachers," *Int. J. Interact. Mob. Technol.*, vol. 14, no. 7, pp. 58–72, 2020. https://doi.org/10.3991/ijim.v14i07.11900

[38] E. Dolzhich, S. Dmitrichenkova, and M. K. Ibrahim, "Using m-learning technology in teaching foreign languages: A panacea during COVID-19 pandemic era," *Int. J. Interact. Mob. Technol.*, vol. 15, no. 15, pp. 20–34, 2021. https://doi.org/10.3991/ijim.v15i15.22895

[39] M. Uğraş, E. Zengin, S. Papadakis, and M. Kalogiannakis, "Early childhood learning losses during COVID-19: Systematic review," *Sustain.*, vol. 15, no. 7, p. 6199, 2023. https://doi.org/10.3390/su15076199

[40] A. Strataki, "An evaluation of educational apps for preschool-age children in Android and iOS," *Advances in Mobile Learning Educational Research*, vol. 2, no. 1, pp. 278–288, 2022. https://doi.org/10.25082/AMLER.2022.01.012

[41] K. Lavidas et al., "Predicting the behavioral intention of greek university faculty members to use moodle," *Sustain.,* vol. 15, no. 7, p. 6290, 2023. https://doi.org/10.3390/su15076290

[42] P. Xu, "Adoption of mobile technologies in learning: An agribusiness case," *Int. J. Technol. Enhanc. Learn.*, vol. 12, no. 3, pp. 343–361, 2020. https://doi.org/10.1504/IJTEL.2020.107996

[43] L. Çetinkaya, "The effects of problem-based mathematics teaching through mobile applications on success," *Egit. ve Bilim.*, vol. 44, no. 197, pp. 65–84, 2019. https://doi.org/10.15390/EB.2019.8119

[44] I. Isrokatun, N. Hanifah, R. Y. Abdul, R. Rosmiati, and R. Khoerunnisah, "The development of android-based learning mobile app to practice critical thinking skills for elementary school students," *Pegem Egit. ve Ogr. Derg.*, vol. 13, no. 2, pp. 161–172, 2023. https://doi.org/10.47750/pegegog.13.02.20

[45] N. Dahal, "Development and evaluation of e-learning courses: validity, practicality, and effectiveness," *Int. J. Interact. Mob. Technol.*, vol. 17, no. 12, pp. 40–60, 2023. https://doi.org/10.3991/ijim.v17i12.40317

[46] M. Nazar, Rusman, K. Puspita, and H. Yaqin, "Android-based mobile learning resource for chemistry students in comprehending the concept of redox reactions," *Int. J. Interact. Mob. Technol.*, vol. 16, no. 03, pp. 123–135, 2022. https://doi.org/10.3991/ijim.v16i03.24133

[47] D. David, A. Novianto, J. Valentino, W. Triyono, N. Chandra, and N. Nadia, "Learning Japanese using speech recognition in educational games," *ICIC Express Lett.*, vol. 15, no. 10, pp. 1093–1099, 2021. https://doi.org/10.24507/ICICEL.15.10.1093

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