



## Developing of mobile learning media as a smart solution to learn everywhere

Fadhilah Khairani<sup>1</sup>, Amrina Izzatika<sup>2</sup>

<sup>1,2</sup> Elementary School Teacher Education, Universitas Lampung, Indonesia

Correspondence: [fadhilah.khairani@fkip.unila.ac.id](mailto:fadhilah.khairani@fkip.unila.ac.id)

### Article Info

#### Article history:

Received Jun 8<sup>th</sup>, 2025

Revised Jun 26<sup>th</sup>, 2025

Accepted Jun 28<sup>th</sup>, 2025

#### Keyword:

Mobile learning media; natural science; product development.

### ABSTRACT

Nearly all teenagers own and consistently use smartphones. Educators should develop diverse and interactive learning media to facilitate students with educational content on their smartphones. This research aims to develop Android-based learning media that can be accessed anytime and anywhere. The study applies three main stages: research and information collecting, planning, and developing, involving 131 respondents and two experts. The research results indicate that the respondents are the type of students who study by involving ICT, interactive learning media, a variety of media, illustrations to understand the concept of the material, and direct experiences or a virtual laboratory. The students needed ICT-based, interesting, effective, and efficient, student-centered, direct experience, no pressing, systematic, demanding critical thinking, character building, variative methods, detailed learning, and others. The preliminary form of the product contained material, animations, interactive simulations, and competency tests that were equipped with recording values for each correct answer. The validation results by education experts showed that android-based mobile learning media that have been developed were declared feasible as independent mobile learning media. Therefore, it is suggested that the product can be used in independent learning as a smart solution.



© 2025 The Authors. Published by Creative Smart Visionary. This is an open access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>)

## INTRODUCTION

The advancement of science and technology, particularly Information and Communication Technology (ICT), has had numerous positive impacts on various aspects of human life, including education. This is especially true in the era of the Fourth Industrial Revolution, where everything is interconnected through various devices, notably smartphones. The integration of ICT in classroom activities has the potential to transform teaching and learning (Djihadah et al., 2023). Universities worldwide are endeavoring to establish online learning (Ali, 2020) to enhance knowledge wealth and the development of pedagogical aspects (Mursid, 2023). Therefore, Android-based multimedia operated on smartphones can enhance students' academic achievements, attitudes, and skills. Additionally, the use of interactive Android-based multimedia during the learning process enables the formation of students' character (Lestari et al., 2019; Nurhikmah H et al., 2020; Sulisty & Kurniawan, 2020). The smartphones used in classroom learning can also enhance interaction between educators and students, as well as among students themselves (Anshari et al., 2017), and enhance students' critical thinking abilities (Sa'diyah et al., 2021). Furthermore, individuals can enhance the quality of their work or performance through technology (Camilleri, 2019).

Almost all teenagers nowadays own smartphones, and half of them tend to use these devices continuously (Vogels et al., 2022). This condition can be both a threat and an opportunity for users (Siebers et al., 2024), especially for students who are still in the process of formal education. The threat will increase if educators do not understand how to leverage products in this digital era. This is because there are numerous Android-based application developers providing attractive and up-to-date products that engage users for hours on their smartphones (Meier et al., 2023). However, the content of these applications may not necessarily be educational for consumption. Therefore, educators need to create similar applications that are theoretically and empirically proven to be suitable, educational, and enhance students' creativity for use in learning.

Nevertheless, the integration of ICT into learning still poses challenges (Mursid, 2023). Educators still face challenges in integrating learning materials into Android-based learning applications (Sunarya et al., 2020). However, the development of Android-based learning applications is crucial, especially considering the curriculum's workload density (Fitriyana et al., 2020). These Android-based learning applications can accommodate learning materials that may not be covered in the classroom. Additionally, interactive digital learning can serve as a solution to concretize some complex and abstract learning concepts (Rejekiningsih et al., 2023).

Students, who are inseparable from smartphone usage, can consistently access installed Android-based learning media. Moreover, the majority of advanced education students own their own mobile phones (Camilleri & Camilleri, 2022). Meaning, students can flexibly learn anytime and anywhere by applying the concept of self-regulated learning (Hendikawati et al., 2019). Especially if the application is designed to display images, sound, two or three-dimensional animations (2D or 3D), simulations, or even showcase video phenomena that are challenging to encounter in everyday life (Widarti et al., 2022). In addition to being engaging and motivating, Android-based learning media will also help students to more easily comprehend the presented material concepts.

One of the developed Android-based learning products is the Android-based Harmonic Oscillation Pocket Book (Bani & Masruddin, 2021). The pocketbook effectively enhances students' cognitive learning outcomes and elicits positive responses. However, the utility of the pocketbook would be more optimal if it incorporates illustrations, animations, and simulations of the learning material concepts. This is especially important when the learning material originates from the field of Natural Sciences, which is rooted in life phenomena, demanding students to understand the relationship between scientific concepts and daily life (Jufrida et al., 2019). Students will better comprehend abstract concepts if natural phenomena are reintroduced into the learning process, either in the form of animations or simulations due to the constraints of space and time, such as in the Solar System material. By leveraging ICT as a foundation in creating learning media that can address these issues, the learning activities will become more effective and efficient (Pratama et al., 2023). This indicates that educational and learning challenges, in general, can be addressed by harnessing technology (Al Mamun & Lawrie, 2023).

Considering the utility of Android-based learning media and the increasing number of non-educational applications, researchers aim to develop Android-based learning media as a complement to blended learning that can be accessed anywhere and anytime through smartphones. Within this framework, answers are sought for the following questions:

RQ1: What are the needs of students in learning?

RQ2: How is the validity of the mobile learning media developed in terms of the material presented?

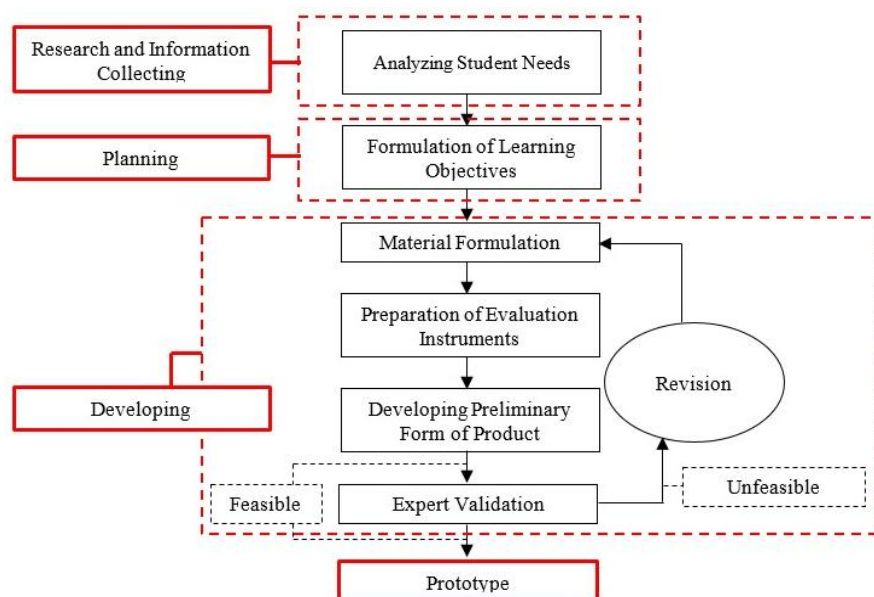
RQ3: How is the validity of mobile learning media developed in terms of ICT?

RQ4: How are the characteristics of mobile learning media considered as a smart solution for learning inside and outside the classroom about the solar system that contains material, animations, interactive simulations and competency tests that are equipped with recording values for each correct answer?

## **RESEARCH METHODS**

### **Research Design**

This research aims to develop a prototype of Android-based learning media. The learning media includes materials accompanied by images/illustrations, simulations, and interactive tests. In the development process, the researcher applies three main steps, namely: 1) Research and Information Collecting; 2) Planning; dan 3) Developing. The development procedure contains the main steps of development research, as shown in Figure 1 below.



**Figure 1. Procedure for Developing Instructional Media**

### Research Participants

The authors engaged 131 students from three universities in Lampung as respondents who would respond to the questionnaire provided to fulfill the Research and Information Collecting stage (refer to Table 1). Participants were not given incentives to take part in this study, and their participation was voluntary. Additionally, subject matter experts and design experts were involved in validating the developed prototype. The selection of experts was based on their proficiency in the aspects to be evaluated during the testing phase.

**Table 1. The Characteristics of Respondents during the Research and Information Collecting Stage**

University of origin	Students in the semester of (%) (N = 131)				
	1/2	3/4	5/6	7/8	> 8
Regular state university (N = 70)	6.87	10.69	19.85	10.69	5.34
Religious-based state university (N = 57)	29.01	-	0.76	7.63	6.11
Private university (N = 4)	-	-	0.76	0.76	1.53

### Collecting Data

The authors employed three main steps in the development of an Android-based instructional media prototype, namely:

#### **Research and Information Collecting**

The research was begun by describing the learning needs of students. This served as a primary consideration in determining the learning objectives and discussing appropriate instructional media for the students. The second author was responsible for this process.

Participants were invited via WhatsApp to take part in the research. By opening the provided link, they could access the questionnaire presented on Google Form. Participants were not required to provide their names but were instructed to fill in information about their university and current semester before answering the research questions. All participants were assured that the questionnaire was anonymous, their responses would be treated confidentially, used only for research purposes, and not shared with third parties.

#### **Planning**

Based on the analysis of student needs and characteristics, the author began developing the instructional media. In this stage, the first author took responsibility for designing an Android-based instructional media. The author established learning objectives for the Solar System content, which is

part of the physics education curriculum at the university level. During this phase, the first author collaborated with the third author, who had expertise in physics, particularly in Solar System topics. The content provided covered information about the sun, inner planets, asteroids, and outer planets. In addition to the instructional content, the author also outlined the presentation flow and its components to ensure that users could easily use and comprehend the presented materials. The developed instructional media includes a home page, main menu, user instructions, learning objectives, content, material reinforcement animations, Solar System simulations, and assessments.

### ***Developing***

In this stage, the first and third authors mapped out the instructional content and its assessment system to be incorporated into the Android-based instructional media. The authors also outlined the learning concepts that needed to be illustrated in the form of images, animations, and simulations to enhance the knowledge transfer process to users. Once everything was mapped out, the first author proceeded to develop the Android-based instructional media.

The developed product was then validated by two experts: a subject matter expert and a media design expert. After undergoing several revisions, the product was approved as an instructional media or, in this case, referred to as a prototype. Considering the feasibility of this prototype based solely on feasibility testing, it is necessary to conduct actual learning trials to determine its empirical feasibility.

### ***Research Instruments***

The research instruments included a student needs assessment instrument and an expert validation instrument. The student needs assessment instrument is open-ended, allowing respondents to provide unrestricted free-form answers. The data obtained is analyzed and used as the basis for determining the specifications of the developed instructional media.

The expert validation instrument is used to gather data on the product's feasibility based on the alignment of design and content regarding the Solar System in the developed prototype. The expert validation instrument, for both content and design assessments, consists of four response options corresponding to the question's content: "Unfeasible" with a score of 1, "Less feasible" with a score of 2, "Sufficiently feasible" with a score of 3, and "Feasible" with a score of 4. In addition to the scoring, experts also provide feedback on the prototype.

### ***Data Analysis***

Data analysis was focused on two main datasets: 1) Student learning needs, and 2) Validation of the Android-based instructional media prototype. The fourth author was responsible for analyzing the characteristics and learning needs of students. For the analysis of student needs, the fourth author applied inductive thematic analysis. Inductive thematic analysis was employed to identify concepts and patterns of meaning within the data (Braun & Clarke, 2006), encompassing the following steps: 1) Familiarizing with the data, (2) Inductive thematic coding, (3) Searching for themes, (4) Reviewing of themes, and (5) Finalization of themes. The iterative approach (i.e., the process of going back and forth between the data, codes, and themes) was followed at various stages to ensure a systematic analysis. Questionnaire data were analyzed using Microsoft Word and Microsoft Excel.

In the validation process, the scores from the validator assessments were converted into assessment statements to determine the feasibility of the developed prototype. The first author was responsible for this stage. The instruments for expert validation had 4 answer choices, allowing the total average assessment score to be calculated using the formula:

$$\text{Rating score} = \frac{\text{Total score on the instrument}}{\text{The sum of the highest total scores}} \times 4$$

The conversion of scores into assessment statements can be observed in Table 2. The results of the data analysis were then incorporated into this paper by the first and fifth authors. The completed paper was subsequently reviewed by the second author to ensure it met standard criteria.

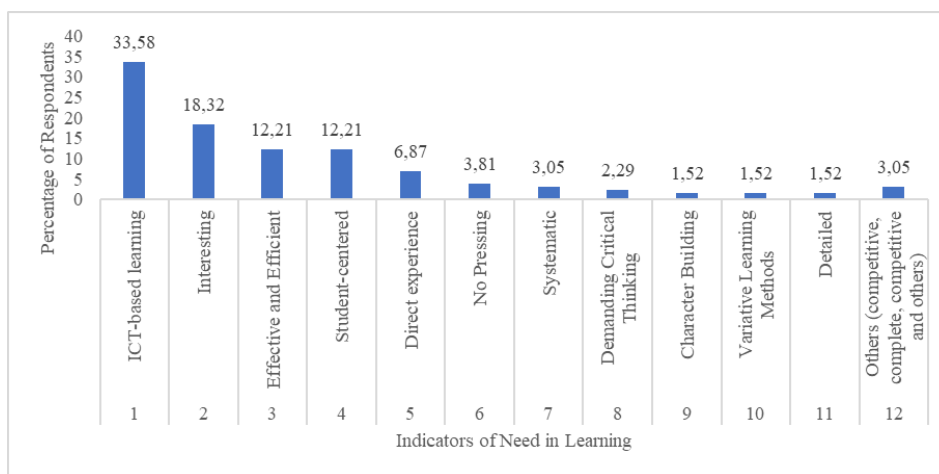
**Table 2. Converting a Rating Score into a Statement of Quality Values (Widoyoko, 2016)**

Rating Score	Average Score	Classification
4	3.26 – 4.00	Feasible
3	2.51 – 3.25	Sufficiently feasible
2	1.76 – 2.50	Less feasible
1	1.01 – 1.75	Unfeasible

## RESULTS

### Needs Analysis

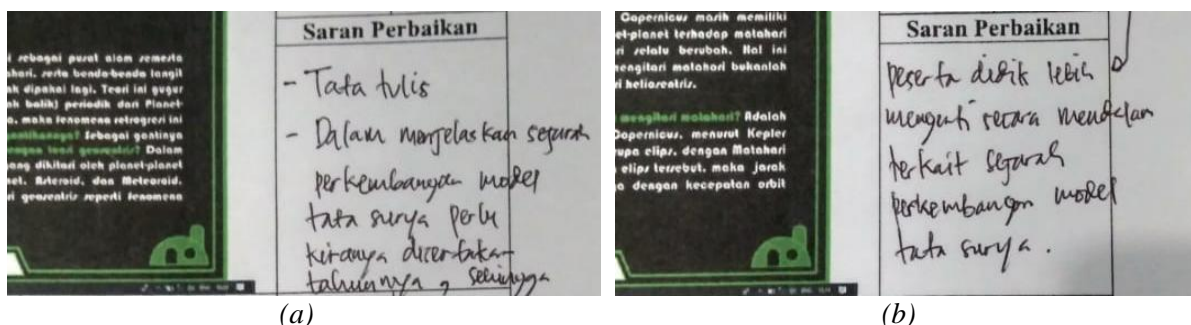
The results of the needs analysis indicate that students prioritize technology-based learning compared to other aspects such as attractiveness, effectiveness, efficiency, and so on, as fully presented in Figure 2. This suggests that the digital era generation recognizes that ICT is a necessity to support and facilitate life activities, particularly in the field of education.



**Figure 2. Percentage of Results of Analysis of Student Needs**

### Content Expert Validation

The validation results indicate that the material expert's assessment score for the developed prototype is 3.34. This score signifies that the prototype is highly suitable for use as a mobile learning media. However, there are some improvements suggested to enhance the prototype. It is advised to tailor the prototype to a specific educational level. The experts recommend that the developed prototype should establish clear learning objectives to provide users with a better understanding of what they will master by using the prototype.



**Figure 3. Suggestions for Improving the Writing and Presentation of the History of the Development of the Solar System Model**

Furthermore, with the established objectives, the developer can focus on presenting relevant content to support the achievement of learning goals. Consequently, the displayed material can be organized systematically. Users can attain the expected objectives without navigating through overly complex content and without missing steps due to insufficient material. Additionally, some simulations

do not align with the actual concepts of physics. For instance, Earth should rotate on its axis with a tilt of 23.5 degrees. Moreover, Earth is not a perfect sphere; the equatorial radius is smaller than the polar radius.

Other suggestions for improvement include addressing writing issues, such as instances where some repeated words are not separated by hyphens (-) (Figure 3.a). Additionally, the material on the history of the development of the solar system model needs to be detailed and organized systematically. Below are some notes for improvement provided by the content expert (Figure 3).

### Design Expert Validation

The validation results for the design indicate that the assessment score for the developed prototype is 3.52. This score suggests that the prototype is highly suitable for use as a mobile learning medium. The validation focused on the functionality of the link buttons from one view to another, text readability, layout, simulation attractiveness, and user-friendliness. Suggestions for improvement are provided in the written text. The font previously used had low readability levels, affecting eye endurance when reading or learning using the developed prototype. Eyes can quickly become fatigued, leading users to use the prototype for a short duration. With such a brief usage time, users are less likely to achieve the expected learning outcomes.

In addition, there are non-functional link buttons, causing one view not to open. Some buttons on other views are also considered inefficient as users need to click them twice to close them before revealing another view. In more detail, there are views that cover buttons to navigate to the next view that should still be accessible. Another improvement is in the testing view. Correct or incorrect comments on user-provided answers need to be displayed, making the test interactive and encompassing all answer options for the next question.

### Prototype of Android-Based Learning Media on Solar System Content

Here are some key insights from the prototype designed based on the analysis of student needs and characteristics, as well as the results of expert validation and revisions (Figures 4, 5, and 6).



Figure 4. Main Menu

This section displays the main interface, where users can access all sections of the prototype. Each button is illustrated by an image or animation corresponding to the view it will navigate to. This is provided so that users who have used the prototype multiple times can access specific content according to their needs without going through everything again.



Figure 5. Instruction

This section provides instructions for using the prototype, starting from opening the application, with the initial view serving as the prototype cover for the author's biography. It is designed for users who are just beginning to use it for learning purposes.



Figure 6. Objectives

This section displays the learning objectives that users will achieve after using the instructional media prototype.



Figure 7. Concept Map

This section presents a systematic mapping of concepts based on the types of solar system objects and the position of the solar system's center. Additionally, the concept map consists of words accompanied by animations of planets or asteroids. Furthermore, the animations serve as buttons to navigate to the corresponding views based on the targeted material.

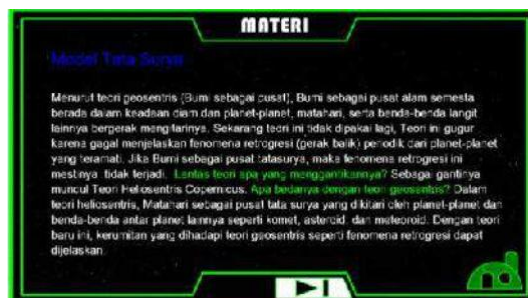


Figure 8. Material I

This section presents the entire material on the solar system, starting from the underlying theories of its formation to the applicable laws. In this material, some questions emphasize important sections (green text). Several concepts in the material are also complemented with animations to enhance the clarity of conveying those concepts.

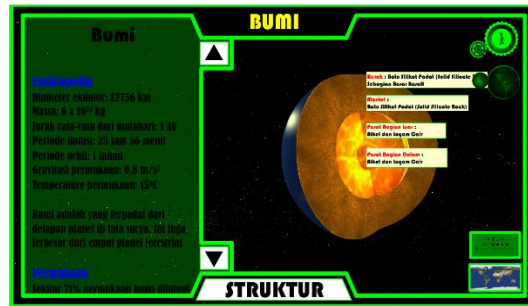


Figure 9. Display of Learning Material

This section provides more specific content, specifically the explanation of the planets in the solar system, accompanied by simulations of planets and satellites, the structure of planets, and views of the planetary surfaces. The goal is for users to have a comprehensive understanding of each object in the solar system.

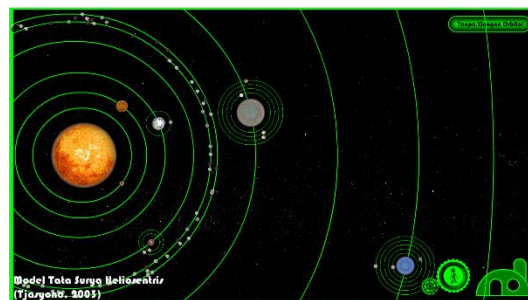


Figure 10. Display of Simulation

This section features a simulation of the solar system according to the heliocentric theory. The orbits of the planets have been adjusted in accordance with Kepler's Laws. However, it should be emphasized that the orbits of the planets are not in a flat plane.



Figure 11. Display of Test

This section presents a series of test questions structured according to the material covered. The interactive test is accompanied by immediate assessment of the answers chosen by the user. It also includes a restart button so that users can review and correct previously incorrect answers.

## DISCUSSION

The first thing to understand before providing interventions to students is to know the characteristics of the students themselves. This is intended so that the treatment given to develop the potential of students can be achieved (Rejekingsih et al., 2023). Appropriate treatment in learning creates a conducive learning environment (Burden, 2020). Students no longer need to adjust to the learning process, especially in the use of ICT-based learning media. Thus, the time previously used to learn the operation of the media can be minimized, allowing students to promptly delve into the content available in the media. Therefore, it is essential to map out how students can learn optimally, particularly in learning that integrates ICT; considering that students live in the digital age where technology has

become an everyday necessity (Maulina et al., 2020). Furthermore, technology is a crucial support for developing 21st-century skills (Latorre-Cosculluela et al., 2021).

Moreover, the use of ICT in creating instructional media is highly flexible, allowing educators or instructors to customize the content based on the conditions and needs of the learners (Lubis, 2018). The development of multimedia technology has a positive impact on changing the way learning occurs in the educational process (Abdulrahman et al., 2020; Nurwidayati et al., 2021). When catering to students with a visual learning style, most developed learning media is presented in the form of images or animations. Learning media will vary for students who have a kinesthetic learning style (Kua et al., 2021). The developed media will be more accurately presented in the form of a virtual laboratory.

Students have turned smartphones into a necessity (Rideout et al., 2022), both for communication and just for playing games. This condition influences the way students learn. Students who are accustomed to understanding the use of Android-based applications through indirectly presented illustrations become a benchmark for understanding the concepts of the material in learning (Kaniawati et al., 2016). Therefore, the existence of ICT-based learning media is highly necessary in education. Besides facilitating access to information, students can also access objects that cannot be presented in the classroom due to spatial and temporal limitations. Thus, ICT-based media allows the presentation of learning material to become more concrete and provides students with the opportunity to interact directly with virtual objects, both physically, mentally, and emotionally (Zahra et al., 2023).

In addition to characteristics in learning, understanding the needs of students is equally important. Moreover, each person has different characteristics. Some students can easily perform activities, but there are also many students who face various challenges in their learning (J.-W. Lin et al., 2016). These different characteristics create different needs. Especially in the current digital era, the convenience offered by technological products shapes students' mindset that practicality is also expected to support learning. In addition to being engaging, learning objectives will be achieved effectively and efficiently when supported by the use of appropriate learning media (Puspitarini & Hanif, 2019).

The characteristics and needs of these students serve as the basis for the development of Android-based learning media that can be accessed anywhere and anytime on the subject of the solar system. This material is presented considering that the presence of objects in the solar system is beyond the reach of students (although Earth is a member of the solar system, it is only a small part). Therefore, this media is highly suitable for presenting the solar system in interactive simulations. Thus, students can still interact virtually with objects in the solar system (Y.-C. Lin et al., 2015).

This media is designed to be very engaging so that users do not quickly get bored when using it for learning. This is evident from the initial display when the media application is opened, namely the cover. In the cover view, a simulation of the Earth's evolution rotating around the sun is followed by the moon. The presentation of this simulation captures the user's attention to continue exploring the media. The trade-off still considers the accuracy of the solar system concept. The direction of revolution and rotation has been adjusted based on the Heliocentric theory. However, the distances between the sun, earth, and moon are overlooked due to limited space on the screen.

Simulations are also presented in the material to reinforce user understanding while reading the content. In addition to simulations, affirmative questions for important concepts are also presented in the material. This is done so that users are emphasized that what they are reading is crucial and useful for understanding the material. Furthermore, the integration of ICT, especially learning media, can create engaging and enjoyable learning activities, enhance student autonomy, and increase learning motivation (Al-Munawwarah, 2014). Thus, the use of ICT can assist educators in enhancing the learning process (Muinde & Mbataru, 2019). In the end, active learning can enhance the quality of education (Parvin, 2013).

Interactive tests are also presented in this media. These tests serve to measure the user's understanding of the solar system material, especially as presented in this media. Each question in the test is accompanied by answer rankings. Thus, users can immediately know whether their answer is correct or incorrect when choosing an answer option. As a result, the benefits of using interactive testing (Freeman et al., 2019) with feedback on actions given in the form of direct scores enhance user memory and understanding.

The advantage of the developed learning media prototype is its high accessibility. Considering that this prototype can be installed on Android-based smartphones, users can access it anywhere and

anytime for individual learning purposes (mobile learning). Mobile learning is effectively applied in education and can motivate students of various age groups, including undergraduate and graduate students aged 16-35 years (Oyelere et al., 2018), as well as students and teachers (Wen & Zhang, 2014). In addition, it has been proven that individual computing programs also have a positive impact on learning practices (Nielsen et al., 2015). This means that there are times when individuals need time to learn independently in their own way to understand learning materials optimally. It also allows individuals to repeat without limitations, which is not possible in group work as it is prone to causing internal conflicts within the group.

With the validation of the developed learning media design, the Android-based solar system learning media prototype is obtained. Theoretically, this prototype is deemed appropriate and effective as a supplementary learning tool both inside and outside the classroom. Therefore, users can access information in this prototype anywhere according to their needs (Uğur et al., 2016).

This convenience gives users plenty of opportunities to learn with the best possible mindset. Sometimes, educators provide good teaching, but at the wrong time (Niemi & Kousa, 2020). With this good learning media, such issues can be overcome. The limitations of face-to-face learning time force the cessation of educational communication between educators and learners. This mobile learning media bridges that limitation with the help of smartphones (Yu et al., 2022) so that students can always interact with learning materials, enhancing their understanding. Therefore, ICT in education can improve the performance of learners and the quality of educators in teaching (Hanaysha et al., 2023).

Although animation is considered a complex medium or too fast to be accurately understood, other research in the field of cognitive psychology reports that the perceived cognitive load when using animated learning media can be reduced or enhanced through the application of instructional design (Lai et al., 2019). Furthermore, well-designed animations or simulations can result in a smaller extraneous cognitive load compared to static image instructions (Yang et al., 2018).

### **Limitations**

Nevertheless, this prototype needs to be tested in actual learning scenarios. It considers that the prototype's feasibility is still assessed from the theoretical perspective of experts. Certainly, the validation and effectiveness of this prototype need to be empirically tested. Moreover, prototype users will be students who are currently in the learning process and have characteristics, backgrounds, and levels of knowledge that differ from the experts. Therefore, further research on the effectiveness of the prototype in learning is needed.

### **CONCLUSION**

Based on the results and discussions, it can be concluded that many students in the current digital era are interested in engaging with TIK-based learning media that are easily accessible, varied, and interactive. This interest places TIK-based learning at the most needed position compared to other aspects (attraction, effectiveness, efficiency, etc.). The characteristics and needs of students in learning serve as the basis for developing an Android-based learning media prototype that complements learning about the solar system, aiming to enhance users' understanding of physics concepts related to celestial bodies. Thus, the product can be used for independent learning as a smart solution and implemented in blended/hybrid learning. However, this prototype needs to be tested in real learning scenarios to assess its effectiveness in education.

### **REFERENCES**

- Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V, Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11). <https://doi.org/10.1016/j.heliyon.2020.e05312>
- Al-Munawwarah, S. F. (2014). TEACHERS' PERCEPTIONS ON THE USE OF ICT IN INDONESIAN EFL LEARNING CONTEXT. *English Review: Journal of English Education*, 3(1), 70–80. <https://journal.uniku.ac.id/index.php/ERJEE/article/view/116>
- Al Mamun, M. A., & Lawrie, G. (2023). Student-content interactions: Exploring behavioural

- engagement with self-regulated inquiry-based online learning modules. *Smart Learning Environments*, 10(1), 1. <https://doi.org/10.1186/s40561-022-00221-x>
- Ali, W. (2020). Online and remote learning in higher education institutes: A necessity in light of COVID-19 pandemic. *Higher Education Studies*, 10(3), 16–25. <https://doi.org/10.5539/hes.v10n3p16>
- Anshari, M., Almunawar, M. N., Shahrill, M., Wicaksono, D. K., & Huda, M. (2017). Smartphones usage in the classrooms: Learning aid or interference? *Education and Information Technologies*, 22(6), 3063–3079. <https://doi.org/10.1007/s10639-017-9572-7>
- Bani, M., & Masruddin, M. (2021). Development of an Android-based Harmonic Oscillation Pocket Book For Senior High School Students. *Journal of Technology and Science Education*, 11(1), 93–103. <https://doi.org/10.3926/jotse.1051>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Burden, P. R. (2020). *Classroom Management: Creating a Successful K-12 Learning Community* (7th ed.). John Wiley & Sons.
- Camilleri, M. A. (2019). The online users' perceptions toward electronic government services. *Journal of Information, Communication and Ethics in Society*. <https://doi.org/10.1108/JICES-09-2019-0102>
- Camilleri, M. A., & Camilleri, A. C. (2022). Learning from anywhere, anytime: Utilitarian motivations and facilitating conditions for mobile learning. *Technology, Knowledge and Learning*, 1–19. <https://doi.org/10.1007/s10758-022-09608-8>
- Djihadah, N., Wasliman, I., Mulyanto, A., & Fatkhullah, F. K. (2023). Literary Teaching Based on Information and Communication Technology (ICT): An Inquiry Approach. *Theory and Practice in Language Studies*, 13(6), 1556–1563. <https://doi.org/10.17507/tpls.1306.25>
- Fitriyana, N., Wiyarsi, A., Ikhsan, J., & Sugiyarto, K. H. (2020). Android-based-game and blended learning in chemistry: Effect on students' self-efficacy and achievement. *Cakrawala Pendidikan*, 39(3), 507–521. <https://doi.org/10.21831/cp.v39i3.28335>
- Freeman, S. C., Kerby, C. R., Patel, A., Cooper, N. J., Quinn, T., & Sutton, A. J. (2019). Development of an interactive web-based tool to conduct and interrogate meta-analysis of diagnostic test accuracy studies: MetaDTA. *BMC Medical Research Methodology*, 19(1), 1–11. <https://doi.org/10.1186/s12874-019-0724-x>
- Hanaysha, J. R., Shriedeh, F. B., & In'airat, M. (2023). Impact of classroom environment, teacher competency, information and communication technology resources, and university facilities on student engagement and academic performance. *International Journal of Information Management Data Insights*, 3(2), 100188. <https://doi.org/https://doi.org/10.1016/j.jjime.2023.100188>
- Hendikawati, P., Zahid, M. Z., & Arifudin, R. (2019). Android-based Computer Assisted Instruction development as a learning resource for supporting self-regulated learning. *International Journal of Instruction*, 12(3), 389–404. <https://doi.org/10.29333/iji.2019.12324a>
- Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education*, 8(4), 630–636. <https://doi.org/10.11591/ijere.v8i4.20312>
- Kaniawati, I., Samsudin, A., Hasopa, Y., Sutrisno, A. D., & Suhendi, E. (2016). The influence of using momentum and impulse computer simulation to senior high school students' concept mastery. *Journal of Physics: Conference Series*, 739(1), 12060. <https://doi.org/10.1088/1742-6596/739/1/012060>

- Kua, M. Y., Suparmi, N. W., & Laksana, D. N. L. (2021). Virtual physics laboratory with real world problem based on ngada local wisdom in basic physics practicum. *Journal of Education Technology*, 5(4), 520–530. <https://doi.org/10.23887/jet.v5i4.4533>
- Lai, A., Chen, C., & Lee, G. (2019). An augmented reality-based learning approach to enhancing students' science reading performances from the perspective of the cognitive load theory. *British Journal of Educational Technology*, 50(1), 232–247. <https://doi.org/10.1111/bjet.12716>
- Latorre-Coscolluela, C., Suárez, C., Quiroga, S., Sobradriel-Sierra, N., Lozano-Blasco, R., & Rodríguez-Martínez, A. (2021). Flipped Classroom model before and during COVID-19: using technology to develop 21st century skills. *Interactive Technology and Smart Education*, 18(2), 189–204. <https://doi.org/10.1108/ITSE-08-2020-0137>
- Lestari, I., Maksum, A., & Kustandi, C. (2019). *Mobile learning design models for State University of Jakarta, Indonesia*. <https://www.learntechlib.org/p/216568/>
- Lin, J.-W., Yen, M.-H., Liang, J.-C., Chiu, M.-H., & Guo, C.-J. (2016). Examining the factors that influence students' science learning processes and their learning outcomes: 30 years of conceptual change research. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(9), 2617–2646. <https://doi.org/10.12973/eurasia.2016.000600a>
- Lin, Y.-C., Liu, T.-C., & Sweller, J. (2015). Improving the frame design of computer simulations for learning: Determining the primacy of the isolated elements or the transient information effects. *Computers & Education*, 88, 280–291. <https://doi.org/10.1016/j.compedu.2015.06.001>
- Lubis, A. H. (2018). Ict integration in 21st-century Indonesian english language teaching myths and realities. *Cakrawala Pendidikan*, 37(1), 11–21.
- Maulina, H., Abdurrahman, A., Sukamto, I., Kartika, N., & Nurulsari, N. (2020). Z-generation learner characteristic and expectation in the RI 4.0 era: a preliminary research in physics teacher college in Lampung. *Journal of Physics: Conference Series*, 1572(1), 12091. <https://doi.org/10.1088/1742-6596/1572/1/012091>
- Meier, A., Beyens, I., Siebers, T., Pouwels, J. L., & Valkenburg, P. M. (2023). Habitual social media and smartphone use are linked to task delay for some, but not all, adolescents. *Journal of Computer-Mediated Communication*, 28(3). <https://doi.org/10.1093/jcmc/zmad008>
- Muinde, S. M., & Mbataru, P. (2019). Determinants of implementation of public sector projects in Kenya: a case of laptop project in public primary schools in Kangundo sub-County, Machakos County. *International Academic Journal of Law and Society*, 1(2), 328–352. [https://iajournals.org/articles/iajls\\_v1\\_i2\\_328\\_352.pdf](https://iajournals.org/articles/iajls_v1_i2_328_352.pdf)
- Mursid, R. (2023). Collaboration-Based Development Model E-Learning on Course Learning Achievements Working Skills. *International Journal of Instruction*, 16(2), 307–318. <https://doi.org/10.29333/iji.2023.16218a>
- Nielsen, W., Miller, K. A., & Hoban, G. (2015). Science teachers' response to the digital education revolution. *Journal of Science Education and Technology*, 24(4), 417–431. <https://doi.org/10.1007/s10956-014-9527-3>
- Niemi, H. M., & Kousa, P. (2020). A Case Study of Students' and Teachers' Perceptions in a Finnish High School during the COVID Pandemic. *International Journal of Technology in Education and Science*, 4(4), 352–369. <https://doi.org/10.46328/ijtes.v4i4.167>
- Nurhikmah H, N. H., Gani, H. A., & Hatta, S. (2020). Android Based Multimedia Learning for Vocational High Schools. *Journal of Educational Science and Technology*, 6(2), 193–204. <https://doi.org/10.26858/est.v6i2.14275>
- Nurwidayati, W., Supriyadi, S., Sukamto, I., & Utami, N. R. (2021). Pengembangan Media Sparkol Videoscribe untuk Meningkatkan Hasil Belajar Kognitif. *Jurnal Manajemen Mutu Pendidikan*,

9(2).

- Oyelere, S. S., Suhonen, J., Wajiga, G. M., & Sutinen, E. (2018). Design, development, and evaluation of a mobile learning application for computing education. *Education and Information Technologies*, 23(1), 467–495. <https://doi.org/10.1007/s10639-017-9613-2>
- Parvin, S. (2013). Integrations of ICT in education sector for the advancement of the developing country: Some challenges and recommendations-Bangladesh perspective. *International Journal of Computer Science & Information Technology*, 5(4), 81. <https://doi.org/10.5121/ijcsit.2013.5406>
- Pratama, K. R., Yamtinah, S., & Roemintoyo, R. (2023). Identifying the Utilization of ICT-Based Interactive Media in School during Pandemic Covid-19. *Journal of Education Research and Evaluation*, 7(1), 88–97. <https://doi.org/10.23887/jere.v7i1.55173>
- Puspitarini, Y. D., & Hanif, M. (2019). Using Learning Media to Increase Learning Motivation in Elementary School. *Anatolian Journal of Education*, 4(2), 53–60. <https://doi.org/10.29333/aje.2019.426a>
- Rejekiningsih, T., Maulana, I., Budiarto, M. K., & Qodr, T. S. (2023). Android-based augmented reality in science learning for junior high schools: Preliminary study. *International Journal of Evaluation and Research in Education*, 12(2), 630–637. <https://doi.org/10.11591/ijere.v12i2.23886>
- Rideout, V., Peebles, A., Mann, S., & Robb, M. B. (2022). The Common Sense Census: Media Use by Tweens and Teens, 2021. *San Francisco, CA: Common Sense*, 1–65.
- Sa'diyah, A., Wilujeng, I., & Nadhiroh, N. (2021). The Effect of Using Smartphone Based Learning Media to Improve Students' Critical Thinking Skills During Covid-19 Pandemic. *6th International Seminar on Science Education (ISSE 2020)*, 374–379. <https://doi.org/10.2991/assehr.k.210326.053>
- Siebers, T., Beyens, I., & Valkenburg, P. M. (2024). The effects of fragmented and sticky smartphone use on distraction and task delay. *Mobile Media and Communication*, 12(1), 45–70. <https://doi.org/10.1177/20501579231193941>
- Sulistyo, W., & Kurniawan, B. (2020). The development of 'JEGER' application using android platform as history learning media and model. *International Journal of Emerging Technologies in Learning (IJET)*, 15(7), 110–122. <https://doi.org/10.3991/ijet.v15i07.11649>
- Sunarya, E. N., Prima, E. C., & Wihardi, Y. (2020). The Development of "E-Layer" Android Mobile Application as Interactive Multimedia in Earth Layer Topics for Junior High School. In R. L.S., P. E.C., H. T., & A. P.J. (Eds.), *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. European Alliance for Innovation. <https://doi.org/10.4108/eai.12-10-2019.2296405>
- Uğur, N. G., Koç, T., & Koç, M. (2016). An analysis of mobile learning acceptance by college students. *Journal of Educational & Instructional Studies in the World*, 6(2). [https://eprints.tiu.edu.iq/980/1/wjeis\\_2016.2.pdf#page=45](https://eprints.tiu.edu.iq/980/1/wjeis_2016.2.pdf#page=45)
- Vogels, E. A., Gelles-Watnick, R., & Massarat, N. (2022). *Teens, social media and technology 2022*.
- Wen, C., & Zhang, J. (2014). Design of a microlecture mobile learning system based on smartphone and web platforms. *IEEE Transactions on Education*, 58(3), 203–207. <https://doi.org/10.1109/TE.2014.2363627>
- Widarti, H. R., Hakim, M. I., & Rokhim, D. A. (2022). The Development of a Virtual Laboratory on Qualitative Chemical Practicum Analysis. *JURNAL ILMIAH PEURADEUN*, 10(3), 785–804. <https://doi.org/10.26811/peuradeun.v10i3.760>
- Widoyoko, E. P. (2016). Teknik penyusunan instrumen penelitian. *Yogyakarta: Pustaka Pelajar*, 15,

22. <http://library.stik-ptik.ac.id/detail?id=49195&lokasi=lokal>

- Yang, C., Jen, C.-H., Chang, C.-Y., & Yeh, T.-K. (2018). Comparison of animation and static-picture based instruction: Effects on performance and cognitive load for learning genetics. *Journal of Educational Technology & Society*, 21(4), 1–11. <https://www.jstor.org/stable/26511533>
- Yu, Z., Yu, L., Xu, Q., Xu, W., & Wu, P. (2022). Effects of mobile learning technologies and social media tools on student engagement and learning outcomes of English learning. *Technology, Pedagogy and Education*, 31(3), 381–398. <https://doi.org/10.1080/1475939X.2022.2045215>
- Zahra, D. N., Saputra, R., & Kesuma, U. (2023). Learning Based on Information and Communication Technology (ICT) in Remote Regions Study of SMAN 3 Tungal Jaya. *Online Conference of Education Research International (OCERI 2023)*, 775, 43. [https://doi.org/10.2991/978-2-38476-108-1\\_6](https://doi.org/10.2991/978-2-38476-108-1_6)