JPPIPA 11(3) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Education for Sustainable (ESD): Development of Android Media to Improve Students' Chemical Literacy

Fazita Apritama Dewi Fau[1*], Agneslina Esterlina Purba[1], Anita[1], Fajar Naqsyahbandi[1], Jajang Muhariyansah[1], Khilda Hasni Ijjati[1], Nurfahraini[1], Umi Arifatun[1], Zahrotul Ma waroh[1]

[1] Chemistry Education, Yogyakarta State University, Yogyakarta, Indonesia.

Received: May 29, 2024
Revised: January 24, 2025
Accepted: March 25, 2025
Published: March 31, 2025

Corresponding Author:
Fazita Apritama Dewi Fau
fazita0006pasca.2020@student.uny.ac.id

DOI: 10.29303/jppipa.v11i3.7835

Abstract: This research aims to develop mobile learning media based on Android media in education for sustainable (ESD) context to improve students' chemical literacy on colloidal system subjects. Scientific issues are presented in each learning activity using this Android-based ESD learning media. The method used in this study was research and development with 4D model development (define, design, development, and disseminate). Media feasibility criteria for Android-based learning media products with ESD contexts on colloidal system materials are based on assessments by material experts, media experts, practicality tests by five teachers, and legibility tests by students. The results of the practicality test of android media by reviewers and peer reviewers showed a very good result and the readability test by students showed a mean score in the very good categoryThe findings confirm that Android-based ESD learning media is practical and effective for teaching colloidal systems in chemistry. The independent sample t-test showed a significant difference in chemical literacy between the control and experimental groups ($p = 0.000 < 0.05$), with an effect size of 2.194, classified as strong. This application enhances students' competencies in sustainable development by fostering awareness of limited natural resources, differentiating sustainable and unsustainable behaviors, and improving ESD-based numerical literacy. Overall, the study validates the feasibility of this media in enhancing students' chemical literacy.

Keywords: Android media; Chemical literacy; Colloid system; ESD

Introduction

The use of Android-based learning media is one of the applications of 21st century learning styles (Calimag et al., 2014). Based on data from Stat Counter Global Stats 2022, Android is the most widely used mobile operating system with a percentage of 90.24 as of June 2023. Technology in education has a role in facilitating the learning process for teachers and students, especially for students who have difficulty understanding lessons in the classroom and outside the classroom (Hafni, 2021). Therefore, teachers must adapt to using online learning media and be able to The use of mobile learning can increase student interest in learning materials and provide opportunities for students to learn material that has not been mastered anywhere and anytime pun (Arista & Kuswanto, 2018; Domingo & Garganté, 2016; Wirawan, 2012).

Science learning, including chemistry, focuses on looking for causal relationships between observed natural phenomena with an emphasis on systematic thinking and reasoning skills (Maturradiyah & Rusilowati, 2015). One of the materials in chemistry learning is colloidal systems studied in Class XI. Colloidal system matter has a close relationship with everyday life especially in everyday scientific issues.

How to Cite:
Fau, F. A. D., Purba, A. E., Anita, Naqsyahbandi, F., Muhariyansah, J., Ijjati, K. H., … Ma waroh, Z. M. waroh. Education for Sustainable (ESD): Development of Android Media to Improve Students' Chemical Literacy. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 216-222. https://doi.org/10.29303/jppipa.v11i3.7835

These scientific issues relate to the use of colloids in various industrial and technological applications such as water and waste treatment, also air pollution treatment from factory waste. The students' understanding of colloidal systems is demonstrated by their ability to relate chemical knowledge in solving problems.

Science literacy is an understanding of scientific knowledge that includes science, technology, society, and the environment (Roberts & Bybee, 2014). Science literacy is not only limited to the ability to read and understand science but also applies science principles in everyday life (Okada, 2013). A similar view related to science literacy is an emphasis on the main role of science knowledge and a view that prioritizes the benefits of science on life in society (Holbrook &; Rannikmae, 2009). Students are required to have this understanding in mastering natural science and technology which refers to science literacy skills (Setiawan *et al*., 2017). Chemical literacy as part of scientific literacy has a special role in chemistry and scientific literacy in general (Mozeika & Bilbokaite, 2010). Chemical literacy includes an understanding of the properties of matter particles, chemical reactions, chemical laws, and theories, as well as chemical applications in everyday life (Imansari *et al*., 2018). The dimensions of chemical literacy include chemical ideas (chemical content), chemistry in context, high-order learning skills, and affective aspects (Laksono, 2018; Shwartz et al., 2005). Conventional habits and a lack of emphasis on scientific reading and writing skills also play a role in reducing scientific literacy (Norris & Phillips, 2003; Sinyanyuri et al., 2022). Furthermore, attitudes toward science, such as interest and comfort in learning science, also influence scientific literacy abilities (Lin *et al*., 2012).

The concept of education for sustainable development (ESD) is present to integrate aspects of sustainable development into chemistry learning. In the context of ESD, SDGs (sustainable development goals) are one of the main focuses to be integrated into the learning process (Hoffmann & Siege, 2018; UNESCO, 2017). ESD is the right educational program to educate humans from an early age to reduce dependence on the natural and social environment (Suduc et al., 2015). Previous research has shown that chemistry classrooms can be an arena for learners to develop ESD competencies as well as acquire knowledge about chemistry (Jegstad & Sinnes, 2015).

The ESD context developed in the learning activities emphasizes aspects such as system thinking, foresighted thinking and strategizing, collaborating, and action orientation. In the system thinking aspect, scientific issues presented in the colloidal system material guide students to think about the interconnections between economic, environmental, and socio-cultural perspectives. This approach aligns with the three pillars of ESD: environment, society, and economy (Indrati & Hariadi, 2016).

In the learning process, teachers encounter difficulties in integrating environmental, social, and economic aspects into a single theme. This issue requires attention, as the implementation of Education for Sustainable Development (ESD) is essential in preparing the younger generation to become individuals capable of facing future challenges, acquiring necessary skills, and acting as responsible members of society (Burmeister, M., & Eilks, 2013). Furthermore, regarding the application of ESD-based learning concepts, teachers agree and believe that these concepts should be implemented in the teaching process (Fitria, A., & Hamdu, 2021). ESD serves as a fundamental approach that enables students to identify various environmental issues and develop appropriate solutions. Therefore, it is necessary to introduce innovative learning strategies through chemistry learning media oriented toward sustainable development. Such innovations can equip students with the necessary knowledge and skills while enhancing their chemical literacy.

This research aimed at developing Android-based learning media within the context of Education for Sustainable Development (ESD) to enhance chemistry literacy has a different focus from previous research that developed Chemistry for Android/ ChemsDro (Wahyudi, 2019). This study emphasizes strengthening chemistry literacy, directing media development not only to improve conceptual understanding but also to cultivate critical and reflective thinking skills in applying sustainability principles. In contrast, the ChemsDro study focuses more on motivating students to care about the environment, particularly in the context of reaction rate material. The key difference between these studies lies in the primary objective of media development. The first study takes a broader approach by integrating conceptual and applied aspects of chemistry literacy within ESD, while the second study specifically aims to foster environmental awareness through reaction rate comprehension. Although both studies are based on ESD principles, they differ in their approach and intended learning outcomes for Android-based educational media.

Therefore, this study was conducted to develop android-based learning media in the context of ESD and determine its effect on the chemical literacy of high school students on colloidal system material.

Method

The type of research was research and development (R&D). The 4D development model is used to conduct research and development for Android Media in the

Education for Sustainable (ESD) context of colloid system subject which includes the define stage, the design stage, the development stage, and the disseminate stage. The types of development research models commonly used in educational research include the 4D model, Borg & Gall, and ADDIE. However, many researchers conducting R&D development studies complete the process only up to the third stage, namely Development. This stage differentiates the 4D model from others, as it does not explicitly include the implementation and evaluation/revision stages. From a rational perspective, the development stage is naturally followed by implementation, as well as evaluation and revision. The 4D model is chosen due to its advantage of being less time-consuming, as its stages are relatively straightforward (Islami et al., 2024; Nur, 2012; Ramadani & Efriyanti, 2022; Saputra et al., 2020; Suryani et al., 2021). The software used in the development of Android media is Adobe Animate CC.

This research was carried out from January 2002 – March 2023, producing the final product in the apps, while product implementation in class was carried out on 1 May – 15 May 2023 with 3 meetings in class and 1 posttest.

The sample was selected using the cluster random sampling technique at SMAN 1 Teluk Dalam, consisting of two eleventh-grade classes: a control class and an experimental class. The validity assessment included theoretical validity and empirical validity. Theoretical validity was conducted through expert judgment based on the developed instrument. Empirical validity was assessed by testing the instrument that had previously undergone theoretical validation. The trial was conducted on students outside the sample class. Empirical validity was analyzed using the Rasch model with the assistance of Winstep software (Boone et al., 2014; Boone & Staver, 2020; Rosli et al., 2020). The reliability of the instrument was determined by examining the item reliability value (Arikunto, 2010) in the Rasch model output.

Data was collected with chemistry teacher interviews, assessment validity for material expert and media experts, teacher and student response questionnaires, also chemical literacy tests. The data was obtained on media feasibility and students' chemical literacy. Media feasibility criteria for Android-based learning media products with an ESD context on colloidal system materials are based on assessments by material experts, media experts, practicality tests by teachers, and legibility tests by students.

The validation of the product and the validation of the test instrument were carried out by subject matter experts and media experts (expert judgment). The validation by subject matter experts included feedback and suggestions on aspects of substance, construction, language, and product characteristics. Meanwhile, the validation by media experts provided input regarding the display, instructional design, and programming aspects. Based on the validation results, it can be concluded that the Android-based media with an ESD context is suitable for enhancing chemical literacy on colloidal system topics.

The revised media product, following expert validation, will undergo a practicality test of the Android-based media with an ESD context. This assessment will be conducted based on evaluations and feedback from teachers/reviewers and peer reviewers, covering aspects of learning, content, design, and product characteristics.

Media feasibility data analysis the formula and converted to interval data. The following equation is then used to:

$$\text{Score} = \frac{total\ score}{number\ of\ respondens} \quad (1)$$

Table 1. Interpretation for Feasibility Score (Mardapi, 2008)

Interval Score	Category
X ≥ (Yi + 1.Sbi)	Very Good
(Yi + 1.Sbi) > X ≥ Yi	Good
Yi > X ≥ (Yi – 1.Sbi)	Poor
X < (Yi – 1.Sbi)	Very Poor

The research subjects were selected using a simple random sampling technique. The android media in the ESD context were implemented on 64 students in class XI IPA 1 and X1 IPA 2 at SMA Negeri 1 Telukdalam using the quasi-experimental method with a posttest only control group design. The instrument used was a matter of chemical literacy in the form of a description of 10 questions. Differences in the chemical literacy of the control class and the experimental class were analyzed using an independent sample t-test and the contribution of learning using the android media in the ESD context was measured using the effect size value with the Cohen's equation (Dunst & Hamby, 2012).

Result and Discussion

Based on product development using the 4D method, the result is the initial design of Android media in the ESD context. The ESD context developed is that learning activities emphasize ESD on aspects of system thinking, foresighted thinking and strategizing, collaborating, and action orientation (Redman, 2013). In the system thinking aspect, there are scientific issues presented in colloidal system material leading students to think about the relationship between economic, environmental, and socio-cultural perspectives. It is based on the three pillars of ESD, namely environmental, social, and economic (Hoffmann & Siege, 2018; Indrati &

Hariadi, 2016; UNESCO, 2005). In the aspect of foresighted thinking and strategizing, collaborative, there are scientific issues that are presented directing students to reflect on positive and negative actions related to issues and the relationship of current activities that have a long impact. In the collaborating aspect, some activities direct students to compile, analyze, and make decisions related to solutions to issues presented in groups. In the aspect of action orientation, some activities direct the implementation of planned activities, write and analyze activities, make conclusions, and understand the benefits of activities that have been carried out for future sustainability. The final design of the Android media in the ESD context can be seen in Figure 1.

Figure 1. The results of Android media in the ESD context

Scientific issues are presented in each learning activity using this Android-based ESD learning media. The first issue discusses colloid types in forest fire cases. The second addresses colloidal properties in alum use for water purification. The third explores colloid formation in jelly production. These scientific issues emphasize ESD aspects from economic, socio-cultural, and environmental perspectives.

Validity and Media Feasibility

Media feasibility based on assessments by material experts and media experts. The result is media experts provide related suggestions and input display aspects, learning design aspects, and programming aspects. Expert material provides suggestions and input regarding aspects of substance, aspects construction, language aspects, and product characteristics aspects. Based on suggestions and input from experts Android media is feasible developed according to the revision provided.

The following Table 2 lists the findings of media feasibility based on teacher response practically. Table 2 reveals that the total score is 70.40 which is a very good category.

Table 2. The result of teacher response practically

Assessment Aspect	Average Score	Category
Learning	14.60	Very Good
Content	17.40	Very Good
Layout	14.20	Very Good
Programming	11.00	Very Good
Product Characteristics	13.20	Very Good
Total	70.40	Very Good

The following Table 3 lists the findings of media feasibility based on student responses of legibility. Table 3 reveals that the total score is 52.60 which is a very good category.

Table 3. Result of student response of legibility

Assessment Aspect	Average Score	Category
Learning	20.92	Very Good
Product Characteristics	31.68	Very Good
	52.60	Very Good

Comparison of Chemical Literacy Between Control and Experimental Classes

Chemical literacy includes an understanding of the characteristics of material particles, chemical reaction processes, chemical laws, and theories, as well as various applications of chemistry in everyday life (OECD, 2013; Toharudin et al., 2011). Hypothesis testing was carried out to analyze whether there were differences in the chemical literacy of students who took part in learning using Android-based learning media with an ESD context in colloid system material. Data analysis used to test the hypothesis was the independent sample t-test with the help of IBM SPSS Statistics 24. The results obtained were that the average score for the experimental class was 90.59 and the average score for the control class was 78.81. Based on the average score, there are differences in chemical literacy between students in the experimental class and the control class. The results indicated it was smaller than the significance level of 0.05 ($0.00 < 0.05$), so H_0 was rejected so it could be concluded that there was a difference in chemical literacy between the experimental and control classes (Table 4).

The developed ESD context in the learning activities emphasizes ESD through aspects of system thinking, foresighted thinking and strategizing, collaborating, and action orientation. In the aspect of system thinking, scientific issues presented in the colloid system material guide students to think about the interconnection between economic, environmental, and socio-cultural perspectives. This is based on the three pillars of ESD: environment, society, and economy (Indrati & Hariadi, 2016). In the aspect of foresighted thinking and strategizing, scientific issues presented encourage students to reflect on both positive and negative actions related to the issue, as well as the longterm impacts of current activities. In the aspect of collaborating, activities are designed to guide students in formulating, analyzing, and making decisions regarding solutions to the issues presented within a group setting. In the aspect of action orientation, activities direct students to implement the planned activities, document and analyze them, draw conclusions, and understand the benefits of the activities conducted for future sustainability.

Table 4. Result of independent test

Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
	Lower	Upper			
11.78125	9.09860	14.46390	8.779	62	0,000

Analysis of the Effectiveness of Android-Based Media in the Context of Education for Sustainable Development (ESD)

According to Table 5, the result of the analysis effect size is 2.194 >0.80 shows that the application of Android-based learning media with the ESD context has high effectiveness because the value of Cohen's d obtained is in the strong category > 0.80. It was concluded that the use of Android-based learning media with the ESD context has a strong influence on students' chemical literacy.

Table 5. Result of analysis effect size

Variable	Effect Size Score	Category
Chemistry Literacy	2.194	Strong

Testing the effectiveness of using Android-based learning media in the context of ESD aims to analyze the magnitude of effective contributions to the chemical literacy of colloidal system materials. This is consistent with research (Zahara & Hamdu, 2022) on the development of learning device applications with an ESD-based android operating system that can develop various self-competencies of students in contributing to sustainable development by respecting limited natural resources, distinguishing sustainable and unsustainable behavior, and literacy explanations such as ESD-based numeracy literacy.

The feasibility of Android-based learning media, which is rated as excellent, has a positive correlation with learning effectiveness. Accessibility, increased motivation, efficiency in concept comprehension, and effective evaluation are key factors that contribute to enhancing the effectiveness of chemistry learning. So, it can be concluded that the use of Android-based learning media in the context of ESD has a strong influence on the chemical literacy of students.

Conclusion

Characteristics of Android-based learning media with an ESD context in the Colloid System developed, include that it can be operated using an Android smartphone and tablet offline, consisting of three learning activities and material with an ESD context. The feasibility of Android-based learning media with an ESD context in Colloidal System material based on the results of the practicality test by reviewers obtained a total average of 70.4 in the very good category and the legibility test results by students were obtained at 52.60 in the very good category. This shows that the Android-based learning media with an ESD context that was developed is suitable for use and application in the learning process of colloid system material for students in class XI semester 2 of SMA Negeri 1 Teluk Dalam, South Nias. There is a difference in chemical literacy between students who take part in learning using Android-based learning media with an ESD context compared to students who do not use Android with an ESD context as shown by the results of the independent sample t-test, a significance value of 0.000 is obtained. This is smaller than the significance level of 0.05. Learning using Android-based learning media with an ESD context provides an effective contribution of 2. 194 in the strong category.

Android-based learning media can be integrated into the chemistry curriculum by aligning materials with educational standards, implementing a blended learning model, and developing interactive features to enhance students' understanding. The use of this application also requires infrastructure support and teacher training for optimal implementation. This media can be easily adopted by other schools if it has high accessibility, is easy to implement, and is equipped with user guidelines. With the right approach, this technology can support sustainable and more effective chemistry learning. In the future, the development of this learning media is expected to serve as an alternative solution to enhance students' chemical literacy more significantly across various chemistry topics.

Acknowledgments

The authors would like to thank SMA 1 Telukdalam, which has supported this research. Without that support, this research would not have been possible to do well.

Author Contributions

The researcher team contributed during the writing of this scientific work, providing concepts, ideas, data collection, analysis and results during the research.

Funding

No external funding.

Conflicts of Interest
No conflicts interest.

References

Arikunto, S. (2010). *Prosedur Penelitian Suatu Pendekatan Praktik*. Rineka Cipta.

Arista, F. S., & Kuswanto, H. (2018). Virtual physics laboratory application based on the android smartphone to improve learning independence and conceptual understanding. *International Journal of Instruction*, *11*(1), 1–16. https://doi.org/10.12973/iji.2018.1111a

Boone, W. J., & Staver, J. R. (2020). Correction to: Advances in Rasch Analyses in the Human Sciences. *Advances in Rasch Analyses in the Human Sciences*. https://doi.org/https://doi.org/10.1007/978-3-030-43420-5_21

Boone, W. J., Yale, M. S., & Staver, J. R. (2014). Rasch analysis in the human sciences. *Rasch Analysis in the Human Sciences*. https://doi.org/https://doi.org/10.1007/978- 94-007-6857-4

Burmeister, M., & Eilks, I. (2013). An understanding of sustainability and education for sustainable development among German student teachers and trainee teachers of chemistry. *Science Education International*, *24*(2), 167–194.

Calimag, J. N. ., Miguel, A. G., Conde, R. S., & Aquino, L. B. (2014). 14. Eng-Ubiquitous Learning Environment Using Android-Luisa B. Aquino. *International Journal of Research in Engineering & Technology*, *2*(2), 2321–8843.

Domingo, M. G., & Garganté, A. B. (2016). Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom. *Computers in Human Behavior*, *56*, 21–28. https://doi.org/10.1016/j.chb.2015.11.023

Dunst, C. J., & Hamby, D. W. (2012). Guide for calculating and interpreting effect sizes and confidence intervals in intellectual and developmental disability research studies. *Journal of Intellectual and Developmental Disability*, *37*(2), 89–99. https://doi.org/10.3109/13668250.2012.673575

Fitria, A., & Hamdu, G. (2021). Pengembangan Aplikasi Mobile Learning untuk Perangkat Pembelajaran Berbasis Education for Sustainable Development. *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran): Kajian Dan Riset Dalam Teknologi Pembelajaran*, *8*(2), 134–145. https://doi.org/https://doi.org/10.17977/um031v8i22021p134

Hafni, R. (2021). Dampak Pandemi Covid-19 Terhadap Pendidikan Online. *Seminar Nasional Teknologi Edukasi Sosial Dan Humaniora*, *1*(1), 601–611.

Hoffmann, T., & Siege, H. (2018). *Education for Sustainable Development - Training of Trainers*. Engagement Global gGmbH.

Imansari, M., Sumarni, W., & Sudarmin. (2018). Analisis Literasi Kimia Peserta Didik Melalui Pembelajaran Inkuiri Terbimbing Bermuatan Etnosains. *Jurnal Inovasi Pendidikan Kimia*, *12*(2), 2201–2211.

Indrati, D. A., & Hariadi, P. P. (2016). ESD (Education for Sustainable Development) Melalui Pembelajaran Biologi. *Symposium on Biology Education*, *12*, 371–382.

Islami, R. D., Kurniati, N., Tyaningsih, R. Y., & ... (2024). Pengembangan Media Pembelajaran Interaktif Berbasis Matematika Realistik. *Journal of Classroom …*, *6*(1). https://www.jppipa.unram.ac.id/index.php/jcar/article/view/7263%0Ahttps://www.jppipa.unram.ac.id/index.php/jcar/article/download/7263/4774

Jegstad, K. M., & Sinnes, A. T. (2015). Chemistry Teaching for the Future: A model for secondary chemistry education for sustainable development. *International Journal of Science Education*, *37*(4), 655–683. https://doi.org/10.1080/09500693.2014.1003988

Laksono, P. J. (2018). Studi Kemampuan Literasi Kimia Mahasiswa Pendidikan Kimia Pada Materi Pengelolaan Limbah. *Orbital: Jurnal Pendidikan Kimia*, *2*(1), 1–12. https://doi.org/10.19109/ojpk.v2i1.2093

Lin, H. S., Hong, Z. R., & Huang, T. C. (2012). The Role of Emotional Factors in Building Public Scientific Literacy and Engagement with Science. *International Journal of Science Education*, *34*(1), 25–42. https://doi.org/10.1080/09500693.2010.551430

Mardapi, D. (2008). *Teknik Penyusunan Instrumen Tes dan Non Tes*. Mitra Cendikia Offset.

Maturradiyah, N., & Rusilowati, A. (2015). Analisis Buku Ajar Fisika Sma Kelas Xii Di Kabupaten Pati Berdasarkan Muatan Literasi Sains. *UPEJ Unnes Physics Education Journal*, *4*(1), 16–20.

Mozeika, D., & Bilbokaite, R. (2010). Teaching and Learning Method for Enhancing 15-16 Years Old Students' Knowledge as One Of Scientific Literacy Aspect in Chemistry: Results Based on Research and Approbation. *The International Journal of Educational Researchers*, *3*(1), 1–16.

Norris, S. P., & Phillips, L. M. (2003). How Literacy in Its Fundamental Sense Is Central to Scientific Literacy. *Science Education*, *87*(2), 224–240. https://doi.org/10.1002/sce.10066

Nur, S. (2012). Pengaruh Pembelajaran Model 4D Terhadap Hasil Belajar Mahasiswa Program Studi

Ppkn Universitas Al Asyariah Mandar. *Pepatuzdu*, *4*(1), 72–87.

OECD. (2013). *PISA 2012 Assessment and Analytical Framework: Mathematics,Reading, Science, Problem Solving and Financial Literacy*. OECD Publishing.

Okada, A. (2013). Scientific Literacy in the digital age: tools, environments and resources for co-inquiry. *European Scientific Journal*, *4*, 263–274.

Ramadani, R., & Efriyanti, L. (2022). Humantech Jurnal Ilmiah Multi Disiplin Indonesia Perancangan Media Pembelajaran Berbasis Android Pada Mata Pelajaran Fikih Untuk Kelas Xi Ips Di Man 1 Pasaman. *Jurnal Ilmiah Multi Disiplin Indonesia*, *2*(1), 106–115.

Redman, E. (2013). Advancing educational pedagogy for sustainability: Developing and implementing programs to transform behaviors. *International Journal of Environmental and Science Education*, *8*(1), 1–34.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. *Handbook of Research on Science Education, Volume II*, *10513*, 545–558. https://doi.org/10.4324/9780203097267.ch27

Rosli, R., Abdullah, M., Siregar, N. C., Abdul Hamid, N. S. Abdullah, S., Beng, G. K., Halim, L., Daud, N. M., Bahari, S. A., Majid, R. A., & Bais, B. (2020). Student Awareness of Space Science: Rasch Model Analysis for Validity and Reliability. *World Journal of Education*, *10*(3). https://doi.org/https://doi.org/10.5430/wje.v10n3p170

Saputra, G. Y., Harjanto, A., & Ningsih, Y. A. (2020). Pengembangan Media Pembelajaran Berbasis Android untuk Mata Pelajaran Fisika Materi Pokok Energi di Kelas X IPA 1 SMA Negeri 2 Muara Badak Tahun Ajaran 2019/2020. *Journal of Advances in Information and Industrial Technology*, *2*(2), 10–24. https://doi.org/10.52435/jaiit.v2i2.67

Setiawan, B., Innatesari, D. K., Sabtiawan, W. B., & Sudarmin, S. (2017). The development of local wisdom-based natural science module to improve science literation of students. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 49–54. https://doi.org/10.15294/jpii.v6i1.9595

Shwartz, Y., Ben-Zv, R., & Hofstein, A. (2005). The importance of involving high-school chemistry teachers in the process of defining the operational meaning of 'chemical literacy.' *International Journal of Science Education*, *27*(3), 323–344. https://doi.org/10.1080/0950069042000266191

Sinyanyuri, S., Utomo, E., Sumantri, M. S., & Iasha, V. (2022). Literasi Sains dan Asesmen Kompetensi Minimum (AKM): Integrasi Bahasa dalam Pendidikan Sains. *Jurnal Basicedu*, *5*(1), 1331–1340. https://doi.org/10.31004/basicedu.v6i1.2286

Suryani, B., Sulandjari, S., Sutiadiningsih, A., & Romadhoni, I. (2021). Pengembangan Media Berbasis Android Kompetensi Dasar Telur Dan Hasil Olahannya Bagi Siswa Smk. *Jurnal Tata Boga*, *10*(1), 194–203. https://ejournal.unesa.ac.id/index.php/jurnal-tata-boga/

Toharudin, U., Hendrawati, S., & Rustaman, H. (2011). *Membangun Literasi Sains Peserta Didik*. Humaniora.

UNESCO. (2005). *ESD: Building A Better, Fairer World for The 21st Century*.

UNESCO. (2017). *Education for Sustainable Development Goals Learning Objectives*.

Wahyudi, T. (2019). *Pengembangan media pembelajaran chemsdro berbasis android berorientasi education for sustainable development (esd) pada materi laju reaksi kelas XI SMA Negeri 1 Kendal* [UIN Walisongo]. http://eprints.walisongo.ac.id/id/eprint/10423/

Wirawan, P. W. (2012). Pengembangan Kemampuan E-Learning Berbasis Web Ke Dalam M-Learning. *Jurnal Masyarakat Informatika*, *2*(4), 21–26. https://doi.org/10.14710/jmasif.2.4.21-26

Zahara, R., & Hamdu, G. (2022). Perangkat Pembelajaran Virtual Field Trip Berbasis Education For Sustainable Development Di Sekolah Dasar. *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran): Kajian Dan Riset Dalam Teknologi Pembelajaran*, *9*(1), 1–13. https://doi.org/10.17977/um031v9i12022p001