https://doi.org/10.24036/jep/vol7-iss1/737

JEP (JurnalEksakta Pendidikan)
Volume 7, Nomor 1, 63 - 73
ISSN:2579-860X (Online), ISSN:2514-1221 (Print)
https://jep.ppj.unp.ac.id/index.php/jep

Developing STEM-Integrated Interactive Multimedia to Improve Students' Data Literacy and Technology Literacy

Serli Ahzari[1], Asrizal[2*]
[1]Physics Education Study Program, Universitas Negeri Padang, Padang, Indonesia.
[2]Physics Department,Universitas Negeri Padang, Padang, Indonesia.

Received: February 21, 2023 ▪ Revised: April 29, 2023▪ Accepted: May 19, 2023

ABSTRACT

Facing industry 4.0 literacy requires a role of literacy. One of the literacies that are suitable for answering the challenges of this era is data and technology literacy. The STEM approach is the learning approach used to address the challenges of the Industry 4.0 revolution. However, the actual conditions in the field describing the application of interactive multimedia by integrating STEM and integrating data and technology literacy in learning still need to be improved. The solution is to develop interactive multimedia by integrating STEM. This research aims to produce valid and practical interactive multimedia by integrating STEM to improve the data and technology of students. The Research & Development stage was completed until limited product testing. The data in this research was obtained from experts' validity and practical results from the students of class 11 science. The data collection instrument consisted of the validity sheet given to the experts and the practicality sheet given to the students of class 11 science. The analysis results show that the STEM-integrated interactive multimedia produced is valid and practical according to students. The second value is included in the very good category. Experts rationally state that interactive multimedia integrating STEM is valid regarding material substance, visual communication display, learning design, software usage, and assessment of STEM components. Students stated that the interactive multimedia presentation integrating STEM was practical regarding usability, ease of use, attractiveness, and clarity.

Keywords: Interactive multimedia, STEM, Data literacy, Technology literacy

INTRODUCTION

The industrial revolution 4.0 demands innovation and creativity in all fields, including education. Education in the industrial revolution 4.0 era supports students' learning and thinking patterns to develop their potential, requiring new literacy. Students must have new literacy to compete in the industrial revolution 4.0 era. Data, technological, and human literacy are three new literacy skills that students must master (Ibda, 2019).

The importance of data literacy and technology literacy is increasing along with the rapid development of technology. Data literacy and technology literacycan assist in understanding and analyzingtechnology-generated data. For example, data from social media, the internet, or other digital devices can provide essential information for decision-making, both personally and professionally. Technology literacy can help someone use existing technology and increase their productivity and creativity in various fields (Anggaira, 2019; Fatmawati & Safitri, 2020).

***Correspondence:**
Asrizal, Physics Department, Universitas Negeri Padang,Padang, Indonesia.
✉email :asrizal@fmipa.unp.co.id
Copyright (c) 2023 Serli Ahzari, Asrizal
This work is licensed under a Creative Commons Attribution 4.0 International License.

Information and Communication Technology (ICT) use in education is essential in the industrial revolution 4.0 era. ICT can help increase learning effectiveness, efficiency, and quality (Asrizal et al., 2022; Yusuf, 2018). In addition, ICT can also facilitate active and participatory collaboration and student involvement in learning. El Janous et al. (2022) state that using ICT in learning can significantly increase student motivation and achievements.ICT in education can also improve students' ability to solve problems, critical (higher-order) thingking, creatively, and collaborate (Fu, 2013).

The STEM approach is suitable for learning in the industrial revolution 4.0 era. Through the STEM approach, students learn to become problem solvers, innovators, inventors, technologically literate, and collaborators who are very important for the future (Asrizal et al., 2022; Yusuf & Asrifan, 2020). The STEM approach connects and integrates science, technology, engineering, and mathematics so that students can connect the knowledge learned at school with real-world contexts (Anggraini & Huzaifah, 2017; Ningrum & Rahmi, 2021). The characteristics of the STEM approach in the 2013 Curriculum are in integrating STEM components to solve problems (Zuryanty, 2021). In addition, the STEM approach can increase students' interest in science-related fields (Ainley et al., 2008). Meaningful learning will be created by integrating knowledge so that students acquire complete knowledge and skills (Asrizal et al., 2018). Therefore, STEM is mandatory and essentialfor learning in the industrial revolution 4.0 era.

After the preliminary study, it was found that there was a difference between the reality and the expected ideal conditions. Questionnaire analysis of teacher responses to using interactive multimedia in high school physics learning got a low average (49.26). It shows weaknesses in using learning media in schools, which are still relatively simple, less interactive, teacher-centered, and less varied. In addition, the software used for making learning media is only limited to Microsoft PowerPoint. Teacher textbooks are not well integrated with STEM. The average integration of STEM in three physics books for class 11 science is 53.30 in the low category. The analysis showed that students' average data and technology literacy skills were 48.44 and 41.32 in the low category.

Several preliminary studies by previous researchers also showed that students' data and technology literacy was still low. Warschauer and Matuchniak (2010) show that US students have limited access to technology and low data literacy.Yurnetti (2020) analyzed the need to develop thematic science teaching materials by integrating new literacy. The score of the new literacy component in science learning from this study is still in the low category. These studies show a need to strengthen students' data and technology literacy to face the challenges of the industrial revolution 4.0 era.

The solution to overcome these problems is to develop STEM-integrated interactive multimedia. STEM is an acronym for Science, Technology, Engineering, and Mathematics. This term was first coined by the United States National Science Foundation (NSF) in the 1990s. Initially, STEM was named SMET (Science, Mathematics, Engineering, and Technology) but was changed to STEM to make it easier to pronounce and strengthen its meaning (Kelley & Knowles, 2016; Mulyani, 2019). STEM has a close relationship with each other. Mathematics is needed to process data in science, while technology and engineering are science applications (Afriana et al., 2016).

One of the learning resources that helps optimize the learning process is interactive multimedia. Presentation of material with audio, images, animation, and video makes it easier for students to understand the material (Gunawan et al., 2017; Sugianto et al., 2013; Tazkia, 2019). Interactive multimedia also makes it easier for teachers to deliver learning materials more interestingly, effectively, and efficiently. Interesting learning can increase students' interest and motivation so that all competencies can be appropriately achieved (Istiqlal, 2017; Tazkia, 2019).

Several previous studies examined interactive multimedia. Khamzani et al. (2015) researched the development of interactive multimedia based on problem-based learning models in physics subjects with dynamic fluid topics for 11th-grade high school students. The results showed that interactive multimedia effectively improved student learning outcomes and helped students to be more active in understanding the material. In addition, Sulaiman (2020) researched the development of mobile learning-based interactive multimedia physics using a website builder and concluded that interactive multimedia is effective in the physics learning process. Furthermore, Ridwan et al. (2021) examined the development of interactive learning media based on problem-based learning models to improve students' creative thinking abilities in physics. The results showed that interactive learning media can increase student engagement, understanding of physics concepts, creative thinking skills, and cooperation and communication skills between students.

Based on this background, it can be argued that this study differs from several previous studies. The novelty in this research is integrating STEM into interactive multimedia and two new literacy components in the industrial revolution 4.0 era: data and technology literacy. For this reason, research to develop STEM-integrated interactive multimedia to encourage students' data and technology literacy needs to be carried out. This study aims to determine the results of the preliminary study, the results of the validity test, the description of the interactive multimedia, and the results of the practicality test of the STEM-integrated interactive multimedia.

METHODS

Research and development is the method in this research. The subject of this research is STEM-integrated interactive multimedia to improve students' data and technology literacy. The development model implemented in this study is the model proposed by Sugiyo (2012). There are six steps of the development model implemented in this study: 1) determine the potential and problems, 2) collect information, 3) design the research product, 4) validate the research product design, 5) revise the research product and 6) test the research product.

Validators or expert appraisers carry out the validation of research products. The five components assessed in the validity test sheet are the appropriateness of the substance of the material, visual communication display, learning design, software use, and assessment of the STEM component. After getting the validation results from the experts, the design revision stage was carried out.

STEM-integrated interactive multimedia is being trialed on a limited basis. This limited trial was conducted on thirty-three students of grade 11 science using a questionnaire sheet. This limited trial aims to find out the practicality of interactive multimedia. Four components are measured for practicality: usability, ease of use, attractiveness, and clarity.

The data collection instrument in this research is a need analysis instrument. The instruments are in the form of questionnaires and interview sheets. Furthermore, the instrument for the design, development, and product trial stages is a questionnaire of product validity and practicality instruments.

Data analysis techniques used descriptive statistics. Descriptive analysis is displayed in tables or graphs. This study assesses the validity and practicality of STEM-integrated interactive multimedia to improve students' data and technology literacy. Data validity and practicality test results are presented in graphics. The developed multimedia's validity and practicality values refer to the following categories of assessment results: 86 to 100 is very good, 71 to 85 is good, 56 to 70 is fair, 40 to 55 is poor, and less than 40 is very poor.

RESULTS AND DISCUSSION

Results

Preliminary Study Results

The preliminary study concernsstudents' data literacy, technology literacy, and knowledge. Students' data literacy and technology literacy data were obtained from work assessment sheets, while students' knowledge data from learning outcomes. Based on initial observations, the results obtained were students' data literacy, technology literacy, and knowledge. The descriptive statistical parameter scores of the data are presented in Table 1.

Table 1. Descriptive Statistical Parameter Scores of Students' Literacy and Knowledge

Statistics Parameter	Data Literacy	Technology literacy	Knowledge
Mean	48.44	41.32	56.06
StandardDeviation	12.62	4.30	18.41
Variance	159.32	18.48	338.80
Lowest Score	31.25	31.25	25.00
Highest Score	75.00	50.00	100.00
Median	46.88	43.75	54.00
Modus	37.50	43.75	55.00
Score Range	43.75	18.75	75.00

From Table 1, the lowest scores from the assessment of students' data literacy, technology literacy, and knowledge were 31.25, 31.25, and 25.00, while the highest scores, respectively, were 75.00, 50.00, and 100.00. The scores of 31.25 and 25.00 mean that literacy and knowledge performance assessment results are in the very poor category, 75.00 is in the good category, 50.00 is in the poor category, and 100.00 is in the very good category. The score range from the performance assessment results of data literacy, technology literacy, and knowledge is 43.75, 18.75, and 75.00.

The average scores of the performance assessment for data literacy, technology literacy, and knowledge are 48.44, 41.32, and 56.06. This average score indicates that students' data and technology literacy are in the poor category, while students' knowledge scores are in the fair category. The modus ofdata literacy, technology literacy, and knowledge assessments are 37.50, 43.75, and 55.00, respectively. These three scores are in the very poor and poor categories. The median scores for students' data literacy, technology literacy, and knowledge were 46.88, 43.75, and 54.00; all were in the poor category. Based on these three assessments, students' data literacy, technology literacy, and knowledge have not achieved the expected results, requiring innovation in learning so that later the results obtained are more optimal and as expected.

The Description of STEM-Integrated Interactive Multimedia

STEM-integrated interactive multimedia developed in this study has uniqueness compared to previous studies. Interactive multimedia in this study uses Articulate Storyline 3 software to make it more practical and interesting. In addition, this interactive multimedia is also equipped with student worksheets as a guide in conducting virtual experiments using PhET Simulation. STEM-integrated interactive multimedia is equipped with interactive quizzes, exercises, and assessment using the Kahoot and Quiziz applications. The goal is that students are more interested in doing it to increase knowledge, data literacy, and technology literacy skills. The developed interactive multimedia products are presented in Figure 1.

Figure 1. Front Display of STEM-Integrated Interactive Multimedia

In the initial display are multimedia identities such as titles, subjects and classes, the Tut Wuri Handayani logo, the product manufacturer's university logo, a personal symbol, a question mark symbol, a volume symbol, and a cross symbol. The personal symbol allows the user to see the identity of the creator of the interactive multimedia. The question mark symbol provides a usage guide that assists the user in understanding how to operate the product effectively. The volume symbol lets the user control the sound output according to the desired preference. Lastly, the cross symbol makes it easy for the user to exit the product quickly. In the initial display, there is also a "start" button; if the user presses the button, the display will lead to the main menu. The main menu display is presented in Figure 2.

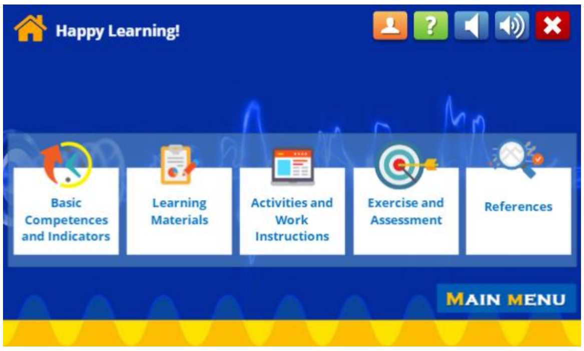

Figure 2. Main Menu Display of STEM-Integrated Interactive Multimedia

The interactive multimedia presented has five main menus covering various learning components. The first main menu is basic competencies and indicators to be achieved, which serve as guidelines for learning objectives. The second is the learning materials menu, which presents subject matter, sample questions, and learning videos to support student understanding. Furthermore, the activities and work instructions menu integrates STEM (Science, Technology, Engineering, and Mathematics) concepts into learning by providing relevant assignments and instructions. In addition, the exercise and assessment menu allows teachers and students to see learning progress and conduct self-evaluations. Finally, the references menu provides a list of references to broaden students' knowledge. Teachers and students can access each interactive multimedia main menu in the learning.

Validity Test Results

The STEM-integrated interactive multimedia validity test results were obtained from the validity sheet instrument given to the expert. Validity assessment was carried out using five evaluation components: material substance (K1), visual communication display (K2), learning design (K3), software use (K4), and STEM assessment (K5). Through data analysis from these instruments, a more comprehensive understanding of the validity and quality of STEM-integrated interactive multimedia in the learning context can be obtained. The plot of the average value of each component is shown in Figure 3.

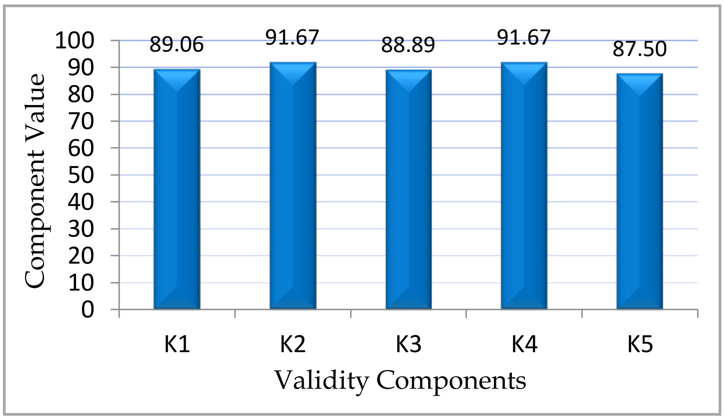

Figure 3. The Average Value of STEM-Integrated Interactive Multimedia Validity Components

Figure 3 shows the average value of each validity component. The average values of the five validity components are 89.06, 91.67, 88.89, 91.67 and 87.50. Based on the average value, the validity value of the material substance, visual communication display, learning design, software use, and STEM assessment are very valid. After the value of each component is analyzed, the average value of the five STEM-integrated interactive multimedia is 89.76. It means that the validity of STEM-integrated interactive multimedia is very valid.

Practicality Test Results

The practicality of STEM-integrated interactive multimedia according to students was obtained from students' practicality test instruments. There are four practicality test components: usability (U1), ease of use (U2), attractiveness (U3), and clarity (U4). Each component has several assessment indicators for student responses to STEM-integrated interactive multimedia. The students involved in this research were thirty-three students of grade 11 science. The average value of the four components are 90.44, 92.05, 92.80, and 92.42. The results of the average value plot for each component are presented in Figure 4.

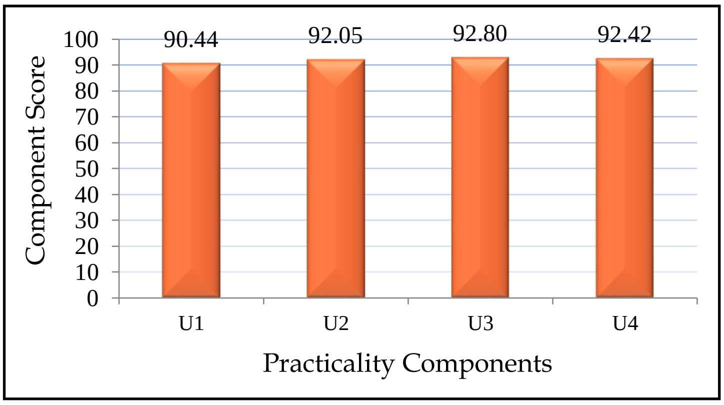

Figure 4.The Practicality Value of Using STEM-Integrated Interactive Multimedia

The first practicality component according to students is usability. The value of the usability component ranges from 84.85 to 93.18. The lowest value is 84.85 on the indicator of increasing student understanding. The highest value is 93.18 on the indicator "students can use the internet and technology (computers, smartphones) wisely using interactive multimedia." Based on the eight indicators' values, the usability component's average value is 90.44 in the very practical category.

The second practicality component according to students is the ease of use. The range of values obtained from the ease of use component indicator is 86.36 to 96.97. The lowest value is 86.36 on the indicator "navigation menu on interactive multimedia is easy to use." The highest value is 96.97 on the indicator "interactive multimedia easily accessible using a smartphone without an application." Based on the eight indicators' values, the usability component's average value is 92.05 in the very practical category.

The third practicality component according to students is attractiveness. The range of values obtained from the attractiveness component indicator is 89.39 – 96.21. The lowest value is 89.39on the indicator "the color combination in each interactive multimedia part is proportional." The highest value was 96.21 on the indicator "interactive multimedia presents quizzes and learning evaluations using the Kahoot and Quizziz applications so that learning is more interesting and fun." Based on the eight indicators' values, the usability component's average value is 92.80 in the very practical category.

The fourth practicality component according to students is clarity. The range of values obtained from the attractiveness component indicator is 88.64 – 95.45. The lowest value is 88.64 on the indicator "activities and work instructions are clear when students carry out experiments." The highest value is 95.45 on the indicator "STEM information presented clearly." Based on the eight indicators' values, the usability component's average value is 92.42 in the very practical category. This resultaligns with Asrizal (2021), who states that clarity is the highest practicality component.

Figure 2 shows the average practicality of STEM-integrated interactive multimedia components. The practicality value for each indicator is obtained in the range of 90.44 to 92.80. It means that the practicality value of each component is in the very practical category. After analyzing the four components, the average practicality value of STEM-integrated interactive multimedia was 91.93 in the very practical category. Based on this average value, STEM-integrated interactive multimedia is in the very practical category.

Discussion

The results of the interactive multimedia validity were analyzed for each component. Based on the analysis results, the validity of STEM-integrated interactive multimedia is very good. The results align with Ilahi (2021) and Yulia (2022), where interactive multimedia is valid regarding the components of material substance, learning design, visual communication display, and software use. It shows that interactive multimedia is made following the structure of developing ICT-based teaching materials, according to the Ministry of National Education (2010).

According to the validator, proper layout, picture illustrations and illustrations and proportional color combinations make interactive multimedia more interesting to read (Fadhilah et al., 2020; Fitri, 2020; Kurniasari et al., 2014). It was concluded that STEM-integrated interactive multimedia is valid in material substance, visual communication display, learning design, software use, and STEM assessment.

Not all STEM-integrated interactive multimedia assessment components achieve perfect values, so revisions are needed. After the revision, STEM-integrated interactive multimedia is better than before, so its practicality can be tested. The practicality test results of STEM-integrated interactive multimedia in this study are based on four components: usability, ease of use, attractiveness, and clarity.

Innovative learning media can make the learning process more interesting and meaningful for students (Dewi & Hilman, 2018; Khaira, 2021; Parlindungan et al., 2020). Interactive multimedia can be used as independent learning material to improve students' conceptual understanding and make it easy for students to evaluate learning independently because they get feedback (Diyana, 2019). Based on the results, students stated that the

STEM-integrated interactive multimedia presentation was practical in terms of usability, ease of use, attractiveness, and clarity.

Interactive multimedia has several advantages, suchasbeing flexible and easy to access on Android devices dan making it easier for students to learn independently (Sulaiman et al., 2020). In addition, interactive multimedia based on mobile learning is economical, effective, and efficient learning media (Rahardjo et al., 2019; Setiadi & Ghofur, 2020; Hingide et al., 2021). Mobile-based interactive multimedia can be used in Physics learning to increase student involvement and enable users to be active (Astuti et al., 2017; Zulham, 2020; Tabrani et al., 2021).

CONCLUSION

Two conclusions can be put forward based on the research results and discussion. First, the validity of STEM-integrated interactive multimedia is very valid. Second, the practical value of interactive multimedia according to students is included in the very practical category. STEM-integrated interactive multimedia is stated to be very valid in the components of material substance, visual communication display, learning design, software use, and STEM assessment. Students also stated that STEM-integrated interactive multimedia presentations were very practical regarding usability, ease of use, attractiveness, and clarity. Thus, STEM-integrated interactive multimedia is very valid and very practicalfor increasing students' data literacy and technology literacy.

REFERENCES

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Penerapan Project Based Learning Terintegrasi STEM untuk Meningkatkan Literasi Sains Siswa Ditinjau dari Gender. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 202-212.

Ainley, J., Kos, J., & Nicholas, M. (2008) *Participation in Science, Mathematics and Technology in Australia Education*. Victoria: The Australian Council for Education Research.

Anggaira, A. S. (2019). Literasi Terkini Dalam Pembelajaran BIPA Pada Era Revolusi Digital. In *Prosiding Seminar Nasional Program Pascasarjana Universitas PGRI Palembang*, 12(1), 29-39.

Anggraini, F. I., & Huzaifah, S. (2017). Implementasi STEM Dalam Pembelajaran IPA di Sekolah Menengah Pertama. *In Seminar Nasional Pendidikan IPA*, 1(1), 722-731.

Anita, Y., Waldi, A., Akmal, A. U., Kenedi, A. K., Hamimah, H., Arwin, A., & Masniladevi, M. (2022). Pengembangan Bahan Ajar Elektronik Berbasis Social and Emotional Learning Untuk Meningkatkan Nilai Profil Pelajar Pancasila Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(4), 7087-7095.

Asrizal, A., Rafika, E., & Triana, A. (2018). Pengembangan LKS IPA Terpadu Tipe Terhubung Berbasis ICT Mengintegrasikan Nilai Karakter Untuk Implementasi Standar Proses Pada Siswa SMP Kelas VIII. *Prosiding seminar nasional pembelajaran* fisika. Padang 7 November 2015, 171-179.

Asrizal, A., Yurnetti, Y., & Usman, E. A. (2022). ICT Thematic Science Teaching Material with 5E Learning Cycle Model to Develop Students' 21st-Century Skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 61-72.

Asrizal, A., Yurnetti, Y., Murtiani, M., & Usman, E., A. (2021). Validity and Practicality of Science Learning Material by Integrating New Literacy Based on Thematic Learning for

Grade VIII Students. In *Journal of Physics: Conference Series* (Vol. 1940, No. 1, p. 012111). IOP Publishing.

Asrizal., A., Mardian, V., Novitra, F., & Festiyed, F. (2022). Physics Electronic Teaching Material-Integrated STEM Education to Promote 21st-Century Skills. *Cypriot Journal of Educational Sciences,* 17(8), 2899-2914.

Astuti, I. A. D., Sumarni, R. A., & Saraswati, D. L. (2017). Pengembangan media pembelajaran fisika mobile learning berbasis android. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *3*(1), 57-62.

Dewi, S., Z., & Hilman, I. (2018). Penggunaan TIK Sebagai Sumber dan Media Pembelajaran Inovatif di Sekolah Dasar. *Indonesia Journal of Primary Education*, 2(2), 48-53.

Diyana, T., N., Supriana. E., Kusairi, S. (2019). Pengembangan Multimedia Interaktif Topik Prinsip Archimedes Untuk Mengoptimalkan *Student Centered Learning*. *Jurnal Inovasi Teknologi Pendidikan*, 6(2), 171-182.

El Janous, Y., El-Hassouny, H., Laafou, M., &Madrane, M. (2022). Effect of ICT on Students' Achievements and Motivation in Life and Earth Sciences Subject. *Pegem Journal of Education and Instruction*, Vol. 12(4), 103-112.

Fadhilah, A., Mufit, F., & Asrizal, A. (2020). Analisis Validitas dan Praktikalitas Lembar Kerja Siswa Berbasis Konflik Kognitif pada Materi Gerak Lurus dan Gerak Parabola. *Pillar of Physics Education*, 13(1), 57-64.

Fatmawati, E., & Safitri, E. (2020). Kemampuan Literasi Informasi dan Teknologi Mahasiswa Calon Guru Menghadapi Pembelajaran di Era Revolusi Industri 4.0. *Edukasi: Jurnal Pendidikan*, *18*(2), 214-224.

Fitri, H. R. (2020). Validitas dan Praktikalitas Bahan Ajar Fisika Materi Kalor dan Teori Kinetik Gas Mengintegrasikan Literasi Baru dan Literasi Bencana Untuk Kelas XI SMA. *Pillar of Physics Education*, *13*(1).

Fu, J.S. (2013). ICT in Education: A Critical Literature Review and Its Implications. *International Journal of Education and Development using Information and Communication Technology (IJEDICT),* Vol. 9(1), 112-125.

Gunawan, G., Harjono, A., & Sutrio, S. (2017). Multimedia Interaktif dalam Pembelajaran Konsep Listrik Bagi Calon Guru. *Jurnal Pendidikan Fisika dan Teknologi,* 1(1), 9-14.

Hingide, M. N., Mewengkang, A., & Munaiseche, C. P. C. (2021). Pengembangan Media Pembelajaran Berbasis Multimedia Interaktif Platform Android Pada Mata Pelajaran PPKN SMK. *Edutik: Jurnal Pendidikan Teknologi Informasi dan Komunikasi*, *1*(5), 557-566.

Ibda, H. (2019). Pembelajaran Bahasa Indonesia Berwawasan Literasi Baru di Perguruan Tinggi Dalam Menjawab Tantangan Era Revolusi Industri 4.0. *Jalabahasa*, 15(1), 48-64.

Ilahi, T. D. W., Mufit, F., & Afrizon, F. (2021). Desain dan Validitas Multimedia Interaktif Berbasis Konflik Kognitif pada Materi Vektor untuk Kelas X SMA/MA. *Jurnal Penelitian Pembelajaran Fisika*, 12(2), 182-195.

Istiqlal, M. (2017). Pengembangan Multimedia Interaktif dalam Pembelajaran Matematika. *JIPMat*, 2(1).

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. In International Journal of STEM Education (Vol. 3, Issue 1).

Kemendiknas. (2010). *Panduan Pengembangan Bahan Ajar Berbasis TIK.* Jakarta: Direktorat Jendral Manajemen Pendidikan Dasar dan Menengah.

Khaira, H. (2021). Pemanfaatan Aplikasi Kinemaster Sebagai Media Pembelajaran Berbasis ICT. In *Prosiding Seminar Nasional Pembelajaran Bahasa dan Sastra Indonesia (SemNas PBSI)-3* (pp. 39-44). FBS Unimed Press.

Khamzawi, S., Wiyono, K., & Zulherman, Z. (2015). Pengembangan Multimedia Interaktif Berbasis Model Pembelajaran Problem Based Learning pada Mata Pelajaran Fisika Pokok Bahasan Fluida Dinamis untuk SMA Kelas XI. *Jurnal Inovasi dan Pembelajaran Fisika*, *2*(1), 100-108.

Kurniasari, D. A. D., Rusilowati, A., & Subekti, N. (2014). Pengembangan buku suplemen IPA terpadu dengan tema pendengaran kelas VIII. *Unnes Science Education Journal*, *3*(2).

Mulyani, T. (2019). Pendekatan Pembelajaran STEM untuk Menghadapi Revolusi Industri 4.0. *Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS)*, *2*(1), 453–460.

Ningrum, M. A. B., & Rahmi, Y. L. (2021). Analisis Kebutuhan Penilaian Capaian Literasi STEM Peserta Didik dalam Pembelajaran Biologi. *Jurnal Eksakta Pendidikan (JEP)*, *5*(2), 156-163.

Oktaviandri, Y., Lubis, M., & Amran, A. (2020). The Effect of STEM-Based Learning Models on Science Process Skills and Critical Thinking of Students in Chemistry Learning. *Journal of Physics: Conference Series*, 1464(1), 012026.

Parlindungan, D. P., Mahardika, G. P., & Yulinar, D. (2020, October). Efektivitas media pembelajaran berbasis video pembelajaran dalam pembelajaran jarak jauh (PJJ) di SD Islam An-Nuriyah. In *Prosiding Seminar Nasional Penelitian LPPM UMJ* (Vol. 2020).

Rahardjo, T., Degeng, I. N. S., & Soepriyanto, Y. (2019). Pengembangan Multimedia Interaktif Mobile Learning Berbasis Android Aksara Jawa Kelas X SMK Negeri 5 Malang. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *2*(3), 195-202.

Ridwan, Y. H., Zuhdi, M., Kosim, K., & Sahidu, H. (2021). Pengembangan Media Pembelajaran Interaktif Berbasis Model Problem Based Learning Untuk Meningkatkan Kemampuan Berpikir Kreatif Fisika Peserta Didik. *ORBITA: Jurnal Kajian, Inovasi Dan Aplikasi Pendidikan Fisika*, *7*(1), 103-108.

Setiadi, M. E., & Ghofur, M. A. (2020). Pengembangan Media Pembelajaran Mobile Learning Berbasis Android dengan Pendekatan Kontekstual pada Mata Pelajaran Ekonomi Kelas X IPS. *Didaktis: Jurnal Pendidikan dan Ilmu Pengetahuan*, *20*(3).

Shahali, E. H. M., Halim, L., Treagust, D. F., Won, M., & Chandrasegaran, A. L. (2018). STEM Education in Malaysia: An Analysis of Policy Documents. *Journal of Science Education and Technology*, 27(6), 541-553.

Sugianto, D., Abdullah, A., G., Elvyanti, S., & Mulyadi, Y. (2013). Modul Virtual: Multimedia Flipbook Dasar Teknik Digital. *Innovation of Vocational Technology Education*, 9(2), 101-116.

Sugiyono. (2012). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung : Alfabeta.

Sugiyono. (2016). *Metode Penelitian Kuanti tatif, Kualitatif, dan Kombinasi (Mixed Methods)*. Bandung: Alfabeta.

Sulaiman, U., Djafar, A., F., & Zulfiana, Z. (2020). Pengembangan Multimedia Interaktif Fisika Berbasis *Mobile Learning* Penggunaan *Website Builder. Jurnal Pendidikan Fisika*, 8(2), 92-98.

Tabrani, M. B., Puspitorini, P., & Junedi, B. (2021). Pengembangan Multimedia Interaktif Berbasis Android pada Materi Kualitas Instrumen Evaluasi Pembelajaran Matematika. *Jurnal Inovasi Teknologi Pendidikan*, *8*(2), 163-172.

Tazkia, Z., Sahyar, S., & Juliani, R. (2019). Web-Based Interactive Multimedia Feasibility at High School Level. *Jurnal Pendidikan Fisika*, *8*(1), 19-28.

Warschauer, M., & Matuchniak, T. (2010). New Technology and Digital Worlds: Analyzing Evidence of Equity in Access, Use, and Outcomes. *Review of Research in Education*, 34(1), 179-225.

Yulia, R., Susanti, E., & Rizal, R. (2022). Pengembangan Multimedia Interaktif Berbasis Android Pada Materi Elastisitas Bahan untuk SMA Kelas XI. *Jurnal Eksakta Pendidikan (JEP)*, *6*(1), 1-10.

Yurnetti, Y., Asrizal, A., & Murtiani, M. (2020). Need Analysis to Develop Science Learning Material Based onThematic Teaching by Integrating the New Literacy. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012122). IOP Publishing.

Yusuf, I., & Asrifan, A. (2020). Peningkatan Aktivitas Kolaborasi Pembelajaran Fisika Melalui Pendekatan STEM dengan Purwarupa Pada Siswa Kelas XI IPA SMAN 5 Yogyakarta: (*Improving Collaboration of Physics Learning Activities through the STEM Approach*). *Uniqbu Journal of Exact Sciences*, 1(3), 32-48.

Yusuf, M. O. (2018). The Role of Information and Communication Technology (ICT) in Education: A review article. *Journal of Education and Practice*, 9(11), 1-9.

Zulham, M. (2020). Keefektifan Multimedia Interaktif Berbasis Mobile dengan Pendekatan Kontekstual untuk Meningkatkan Social Skill dan Kemampuan Berfikir Kritis Pada Materi Gerak dan Gaya. *Jurnal Penelitian Pembelajaran Fisika*, *11*(2), 209-214.

Zuryanty, H. A. (2021). *Pembelajaran STEM di Sekolah Dasar.* Yogyakarta: Deepublish.