Development of Inquiry-Based Solar System Augmented Reality Science Learning Media

Yonatan Vari[1*], Sarwanto[1], Sri Yamtinah[1]

[1] Program Studi Magister Pendidikan Sains, Universitas Sebelas Maret, Surakarta, Indonesia.

Abstract: Science learning in the 21st Century needs to adapt to technological developments in the Era of Revolution 4.0. 21st Century science learning uses digital technology, namely Augmented Reality combined with an inquiry learning model on the Solar System material. The research aims to determine the feasibility of the Inquiry-based Solar System Augmented Reality (SSAR) Learning Media being developed. Inquiry-based SSAR Learning Media Research is development research that uses the ADDIE Development Model with assessment by 8 validators using a 1-5 Likert scale. Inquiry-based SSAR learning media which was developed through the Analysis, Design and Development stages. The Analysis stage is carried out through an initial preliminary study to determine needs analysis. The results of the needs analysis are used in the design stage and then realized in the Development stage. The Media Development stage carried out a feasibility test through validation by 8 experts. The feasibility of SSAR Learning Media is reviewed including Media, Material, Learning and linguistic aspects. The results of the assessment by the Validator were analyzed using the Aiken formula with validation criteria > 0.75. Inquiry-based SSAR Learning Media indicators based on Aiken Validation analysis obtained validation results with a score of 0.85 > 0.75 indicating that Inquiry-based SSAR Learning Media is suitable for use in the science learning process on Solar System material

Keywords: Aiken Validation; Instructional Media; Inquiry-based SSAR

Introduction

Education in the 21st Century is currently in the Era of Revolution 4.0 which is characterized by the existence of automation, computing, Internet of Things (IoT), Artificial Intelligence and Big Data systems (Ismail et al., 2020; Retnaningsih, 2019). The era of Industrial Revolution 4.0 requires students to have 21st century skills consisting of Critical Thinking, Collaboration, Communication and Creativity (Trilling & Fadel, 2009).

21st Century skills development is carried out by utilizing developments in digital technology in the learning process (Eva et al., 2020; Indarta et al., 2022 ; Khairunnisa & Aziz, 2021). The 21st century skills that are needed to be developed in the learning process because they will help students make decisions about problems in student life are critical thinking skills (Ilhamdi et al., 2020). Critical thinking skills are

something that needs to be developed in the learning process at school.

The critical thinking ability score of students in Indonesia in the fields of Mathematics and Science based on the results of the Trends in International Mathematics and Science Study (TIMSS) shows that the critical thinking ability of students in Indonesia is consistently at the bottom of the ranking (Syamsul & Novaliyosi, 2019). Research conducted by Khasani et al. (2019) found that students' low critical thinking abilities are influenced by several factors that occur in the learning process such as learning models, learning media, learning resources and student motivation (Khasani et al., 2019).

Critical thinking skills can be developed through 21st century learning processes that utilize digital technology as a learning medium. The era of Industrial Revolution 4.0 demands student development through

the use of developments in digital technology in the learning process (Eva et al., 2020; Indarta et al., 2022 ; Khairunnisa & Aziz, 2021). Peña-Ayala dalam (Rahmawati & Atmojo, 2021) stated that 21st century learning is a learning process that uses a variety of digital-based media by utilizing sophisticated technology. Science learning that uses digital-based media will foster students' critical thinking skills so that the concepts they acquire can be applied (Ritonga et al., 2020).

Science as a subject in schools needs to adapt to current developments in digital technology and the nature of science learning. Science learning according to Hifni in (Muiz, A., 2016) is learning that is composed of scientific method activities, scientific knowledge and attitudes. Science learning is learning that trains students to learn through a scientific process regarding natural phenomena so that they discover new scientific products through a scientific process that is based on a scientific attitude.

Implementation of 21st century learning that utilizes digital technology in science learning needs to involve students in investigative activities (Aryani et al., 2019; Trianto, 2010). Science learning research activities in the 21st century need to combine learning models that focus on scientific research with learning media that is appropriate to developments in digital technology.

Media that is combined with learning models needs to adapt the learning process to the demands of integrating digital technology as a learning medium so that it can direct students to carry out scientific investigations (Rahayu et al., 2022). The learning process of integrating digital technology which is available as a learning medium can be applied in the classroom using digital technology in the form of applications on Android smartphones. Research conducted by KEMDIKBUD on students in Indonesia found that although students are one of the largest groups of Android smartphone users, only 20% use them for education (Kemdikbud, 2019).

The research conducted by KEMDIKBUD is in line with the initial preliminary studies carried out in schools. Based on the results of the preliminary study, it was found that 91.7% of teachers used video and image media in the learning process and 33.3% of teachers used Android applications as learning media. The percentage of use of learning media that is interactive and relevant to current technological developments, namely Android applications, is quite low. Learning media problems were found in the learning process with 58.3% of students stating difficulties in understanding the material and 33.3% stating that the learning media used were considered less interesting and practical. Learning media is considered by students to be uninteresting and

difficult for students to understand because 75% of teachers sometimes create their own learning media. The use of learning media has an impact on students being less active in the learning process.

Student activity in the learning process is also influenced by the learning process which is dominated by assignments and independent learning with a percentage of 58.3%. The learning process that directs students to discover knowledge has a percentage of 10.6%. The choice of learning media that is less interesting and interactive and the difficulty in implementing learning models that can lead students to discover their own knowledge has an impact on student interest.

Students who are less interested in the learning process cause students to not play an active role in the learning process and based on preliminary studies conducted it was found that 75% of teachers stated that students' lack of activity in the learning process was the main obstacle faced during the science learning process. The active role of students in the science learning process according to (Syofyan & Halim, 2017) This is necessary in order to improve students' critical thinking skills because learning that involves students more will provide students with opportunities to develop ideas and opinions which will lead to the development of critical thinking skills. The influence of students' active role on students' critical thinking abilities is in line with the average score of students' initial critical thinking abilities which is in the low category, namely 38.

Based on the initial preliminary study, students need to be directed in the science learning process at school to take advantage of existing digital technology developments. Digital technology that can be utilized in the science learning process is Augmented Reality (AR). Use of AR according to (Abdul Bujang et al., 2020) is a new learning tool that very well supports the learning process using digital technology (Hamid et al., 2020). AR in learning is useful in explaining learning concepts that are abstract or cannot be presented in real terms (Siahaan et al., 2019). AR was chosen as a learning medium because AR can provide direct experience in science learning by displaying natural phenomena in 3D form so that it trains students to imagine and understand an object displayed by AR (Iqliya & Kustijono, 2019), so that it helps in explaining learning concepts (Siahaan et al., 2019). AR Learning Media provides experiences through 3D objects which will direct students to be able to imagine and understand objects so they can understand science concepts.

Herliandry et.al (2020) stated that the use of AR media needs to be combined with a learning model to encourage students to analyze science concepts as a whole (Herliandry et al., 2021) through scientific

investigation activities. This opinion is supported by the statement by the National Science Education Standards (1996) which states that science is an inquiry (Council, 1996). The Inquiry learning model is a learning model that trains students to express the problems they face and find solutions to these problems so that they can develop students' critical thinking skills (Anggareni et al., 2013; Muakhirin, 2014). Based on this, it can be concluded that the inquiry learning model as a learning model is suitable for science learning. The development of Augmented Reality Learning Media combined with an inquiry learning model on Solar System Material needs to be carried out in the science learning process in order to increase student activity in the learning process. Science learning media needs to be tested for feasibility before being used in the science learning process. Based on the description above, it is necessary to know the feasibility of the Inquiry-based Solar System Augmented Reality (SSAR) Learning Media which was developed before being used in the science learning process to develop students' critical thinking skills.

Metode

Types of research

Research to determine the feasibility of inquiry-based SSAR media is included in the type of development research that uses the ADDIE development model. Implementation of Innkuri-based SSAR Media Development includes the stages of Analysis, Design and Development.

The development of SSAR learning media begins with the Analysis stage. The analysis stage was carried out by conducting an initial preliminary study at SMP Negeri 2 Palangka Raya, SMP Negeri 8 Palangka Raya and St. Catholic Middle School. Paul Palangka Raya. The results of the initial preliminary study to carry out a needs analysis in the learning process.

The results of the initial preliminary study analysis are used as a basis for the Inquiry-based SSAR Learning Media Design stage. The Design Stage is the stage of creating a design for Inquiry-based SSAR Learning Media. The Inquiry-based SSAR Learning Media Design is used in the next process, namely the Development stage.

The Development stage is the stage of creating Inquiry-based SSAR Learning Media which has been designed at the design stage. Development of Inquiry-based SSAR Learning Media using Unity 3D 2022 software. The Inquiry-based SSAR Media that was developed was then tested for feasibility through validation by 8 experts covering media, material, learning and linguistic aspects. The validation results obtained were analyzed using Aiken Validity. Inquiry-based SSAR Learning Media is declared feasible with criteria > 0.75.

Research Instrument

The research instruments used to determine the feasibility of SSAR Learning Media are an Initial Preliminary Study Questionnaire and a validation assessment questionnaire for 8 experts covering media, material, learning and linguistic aspects.

Data analysis technique

Research data sources for the development of inquiry-based SSAR Learning Media from validators are used as validation of media, material, learning and linguistic aspects. The data collection method in this research is the validation method using a validation sheet instrument. Validation data obtained using a Likert scale can be seen in Table 1.

Table 1. Skala Likert

Percentage	Criteria
5.00	Very good
4.00	Good
3.00	Enough
2.00	Not enough
1.00	Very less

Source : (Angga et al., 2022)

The data on the validation sheet is processed using the Aiken's V analysis technique. The formula for calculating the Aiken's V validity coefficient is as follows Formula 1 (Lewis. R. Aiken, 1985).

$$V = \frac{\sum_{x=1}^{x=n} s}{[n(c-1)]} \tag{1}$$

Information:
$s = r - l_0$
l_0 = the lowest validity assessment number
c = highest validity assessment number
r = the score given by the assessor
n = Number of Validators

The validation results whose percentages are known are then compared with the product validity criteria of 0.75 based on the number of Validators, namely 8 and the number of ratings, namely 5 (Lewis. R. Aiken, 1985). If the validation results are > 0.75 then the Inquiry-based SSAR Learning Media is considered valid.

Results and Discussion

Development of Inquiry-based SSAR Learning Media at the Analysis stage begins by distributing

questionnaires to teachers and students. The Analysis stage is carried out with the aim of finding out students' needs for learning media and becoming a basic reference in the learning media design process.

Figure 1. Inquiry-based Solar System Augmented Reality (SSAR) Media Display

The results of the Analysis Stage are followed up with the Design Stage. The Design stage is carried out by researchers creating learning media designs based on the results of needs analysis and consulting on learning designs with experts. Based on the Development Stage, researchers developed inquiry-based AR learning media. The results of the Inquiry-based Augmented Reality Learning Media development product are shown in Figure 1.

In the Development Stage, the researcher carried out a development process which was followed by an assessment by the validator of the Inquiry-based AR Learning Media being developed. Validity is a measure to show how good the quality of a media is (Arikunto, 2013). Media validity is reviewed from the results of product validation by expert lecturers covering 4 aspects, namely media, material, learning and language. Validation score results for each aspect were obtained from validation sheets filled in by 8 validators, by providing a check list (√) on the available assessment scale. The results of the validity of Inquiry-based Augmented Reality Learning Media in each aspect are shown in the diagram in Figure 2.
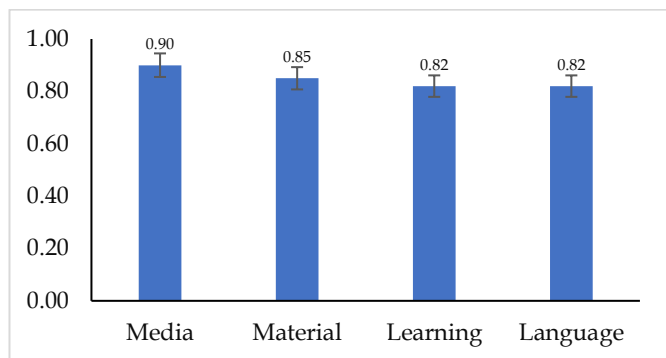

Figure 2. Validation Results of Inquiry-based SSAR Learning Media in each Aspect

In all aspects that have been validated, it can be seen that each aspect is within the valid criteria. This shows that the media that has been developed is valid for use as inquiry-based SSAR learning media, especially on Solar System Material. The material in this media includes the Solar System, Celestial Objects, Rotation and Revolution of the Earth and Rotation and Revolution of the Moon. Assessment of Inquiry-based AR Learning Media in the Material aspect obtained a validation score of 0.85 based on the Content Usefulness and Content Adequacy Indicators. The Content Usefulness indicator shows that Inquiry-based SSAR Learning Media in the material aspect meets learning needs.

The Content Usefulness indicator shows that inquiry-based AR learning media in the material aspect meets learning needs in the curriculum and is relevant to daily events experienced by students and has various variations in displaying information. The material in Learning Media is equipped with 3D objects and relevant information in the form of text, images and videos that support explanations, making it easier to understand. Various variations in displaying information to adapt to student learning needs (Sharma, 2019).

The Content Adequacy indicator shows that inquiry-based AR learning media in material aspects is in accordance with students' abilities so that it is able to encourage students to collect information accurately. Research conducted by Herliandry et.al (2021) found that the visual display of Augmented Reality was able to stimulate students to think and process the knowledge gained (Herliandry et al., 2021). Learning media that displays 3D animation and visualization that supports material needs allows students to collect information accurately so as not to give rise to misconceptions and misinterpretations. Learning media can be one of the causes of misinterpretation and misconceptions in delivering material (Rizki & Setyarsih, 2022). A description of the assessment indicators contained in the validation of the Material aspects can be seen in Table 2.

Table 2. Material Aspect Assessment Indicators

Material Aspect Assessment Indicators	Validation Value
Content Usefulness	0.88
Content Adequacy	0.83

Modification from source: (Almaiah et al., 2016; Ellizar et al., 2018)

Development of Inquiry-based SSAR Learning Media based on validation results, namely 0.90 with valid criteria showing that the development of Learning Media has worked well when installed and used with an

Android Smartphone. Assessment of Inquiry-based AR Learning Media on Media Aspects seen from the indicators of Accessibility, Functionality, Interactivity, Easy of Use, Interface Design, Availability, Personalization and Responsiveness. The Accessibility indicator shows that Inquiry-based SSAR Learning Media is easy to install and open on various types of Android smartphones. The Functionality and Responsiveness indicators show that moving between menus and buttons on Media can respond quickly and function well. Menus and buttons that function are an indication that the media is easy to operate and runs smoothly and responsively. According to Risdiyanto (2018), the development of learning media that runs smoothly and is responsive aims to make it easier for students to search for, process and construct knowledge which results in achieving learning goals optimally. (Putra et al., 2020).

The Interactivity and Availability indicators show that the 3D objects displayed by Inquiry-based SSAR Learning Media can represent the original form as well as the availability of a variety of information displays and features that support student interaction with existing learning media. Easy of Use is an indicator that measures the ease of operating Inquiry-based AR Learning Media without students needing to have special skills. Interface Design is an indicator that represents the appearance of the existing menu including size, resolution, User Interface, menu layout arrangement, menu design and consistency of color display, icon symbols, text type and size. Personalization is an indicator that shows that inquiry-based SSAR Learning Media can be adapted to students' learning needs, with students being able to determine the order of the material they want to study and being able to adapt it to students' learning styles. Learning media that is interesting, interactive and appropriate to students' learning needs can reduce a static atmosphere and can create an effective, interesting, interactive and fun learning process (Novita & Harahap, 2020). Description of the indicator assessment contained in the Media Aspect validation shown in Table 3.

The learning process using Inquiry-based SSAR Learning Media needs to direct students to carry out investigations to find knowledge independently through a series of inquiry learning activities. Assessment of Inquiry-based SSAR Learning Media in the Learning aspect obtained a validation score of 0.82 with valid criteria so that existing Learning Media can be used to carry out learning using an inquiry model. Assessment of Inquiry-based SSAR Learning Media on Media Aspects seen from the Attraction and Compatibility with the inquiry model indicators.

Table 3. Media Aspect Assessment Indicators

Media Aspect Assessment Indicators	Validation Value
Accessbility	0.88
Functionality	0.91
Interactivity	0.92
Easy of Use	1.00
Interface Design	0.90
Availability	0.94
Personalization	0.81
Responsiveness	0.88

Modification from source: (Almaiah et al., 2016; Ellizar et al., 2018)

The Content Attraction and Compatibility with the inquiry model indicators are indicators that Inquiry-based SSAR learning media is able to present various activities that direct students to play an active role in discovering knowledge in science learning and are in accordance with the steps of the inquiry learning model. Science learning media needs to be combined with the implementation of an inquiry-based learning model so that it can convey information that stimulates students' thoughts, feelings, attention and curiosity, thereby encouraging a learning process from within themselves according to learning objectives (Masithah et al., 2022). Inquiry-based SSAR Learning Media needs to be integrated in its development according to the steps in the Inquiry Learning Model. Research conducted by Nuzulah et.al (2023) found that inquiry-based learning content can improve students' good scientific argumentation skills (Nuzulah et al., 2023). Scientific argumentation skills require students' critical thinking skills when presenting scientific arguments. Description of the assessment indicators contained in the validation of the Learning Aspects shown in Table 4.

Table 4. Indicators for Assessment of Learning Aspects

Indicators for Assessment of Learning Aspects	Validation Value
Attraction	0.79
Compatibility with the inquiry model	0.86

Modification from source: (Almaiah et al., 2016; Ellizar et al., 2018)

Another aspect of Inquiry-based SSAR Learning Media is language. The Inquiry-based SSAR Learning Media assessment in the linguistic aspect obtained a validation score of 0.82. Assessment of Inquiry-based SSAR Learning Media on Linguistic Aspects can be seen from language indicators that are straightforward, communicative, in accordance with language rules and easy to understand for junior high school students. The use of language that is easy to understand in learning media is very important in learning so that it makes it

easier for students to learn (Risma Agustina et al., 2022). Research conducted by Cahyati (2020) found that the use of language to help students understand learning material and the process of discovering knowledge concepts thereby improving critical thinking skills. (Cahyati, 2020). The description of the assessment indicators contained in the validation of the Linguistic Aspect is shown in Table 5.

Based on the description above, Inquiry-based SSAR Learning Media in all aspects of Inquiry-based Augmented Reality Learning Media is suitable for use in the science learning process on Solar System Material with an average validation assessment score of 0.85. Inquiry-based SSAR Learning Media is said to be suitable for operation on Android Smartphones in the Media Aspect. Inquiry-based SSAR Learning Media as a medium is certainly found to have appropriate material so that it is used in the learning process in terms of the material aspect. The science learning process through Inquiry-based SSAR Media based on validation results shows that it is in accordance with the steps in science learning in terms of the Learning Aspect and the suitability of students in understanding the existing learning media in terms of the Linguistic Aspect. Linguistic aspects based on research (Panjaitan et al., 2020) shows that the appropriate use of language is appropriate to student development to avoid students' difficulties in mastering and understanding learning material.

Table 5. Indicators for Assessment of Linguistic Aspects

Indicators for Assessment of Learning Aspects	Validation Value
Straightforward	0.79
Communicative	0.81
Suitability to Student Development	0.88
Conformity to Language Rules	0.81

Modification from source: (Almaiah et al., 2016; Ellizar et al., 2018)

The development of inquiry-based SSAR learning media is said to be suitable for use with several revisions from the validator. The results of this are in line with research conducted by (Basyir et al., 2020; Fakhrudin et al., 2017; Iqliya & Kustijono, 2019; Oktaviani et al., 2020; Permana et al., 2019; Setyawan et al., 2019) states that the Augmented reality learning media developed is valid for use in learning. (Mashami et al., 2021) states that Augmented Reality Learning Media can improve students' critical thinking skills (Mashami et al., 2021).

Conclusion

Based on the research results, it can be concluded that the Inquiry-based Solar System Augmented Reality (SSAR) Learning Media is suitable for use in learning with an average feasibility value of 0.85 which includes media, material, learning and linguistic aspects.

Author Contributions
The first author, Yonatan Vari contributed to research design, instrument preparation, research implementation, data collection and analysis, and article writing. The second and third authors, namely Sarwanto and Sri Yamtinah, guided the research process and contributed to writing the article.

Conflict of interest
The authors declare no conflict of interest.

Reference

Abdul Bujang, S. D., Selamat, A., Krejcar, O., Maresova, P., & Nguyen, N. T. (2020). Digital learning demand for future education 4.0-case studies at Malaysia education institutions. *Informatics*, *7*(2), 1–11. https://doi.org/10.3390/informatics7020013

Almaiah, M. A., Jalil, M. A., & Man, M. (2016). Extending the TAM to examine the effects of quality features on mobile learning acceptance. *Journal of Computers in Education*, *3*(4), 453–485. https://doi.org/10.1007/s40692-016-0074-1

Yovan, R. A. R., & Kholiq, A. (2022). Pengembangan media augmented reality untuk melatih keterampilan berpikir abstrak siswa SMA pada materi medan magnet. *PENDIPA Journal of Science Education*, *6*(1), 80-87. https://doi.org/10.33369/pendipa.6.1.80-87

Anggareni, N. W., Ristiati, N. P., & Widiyanti, N. L. P. M. (2013). Implementasi strategi pembelajaran inkuiri terhadap kemampuan berpikir kritis dan pemahaman konsep IPA siswa SMP. *Jurnal Pendidikan dan Pembelajaran IPA Indonesia, 3*(1). Retrieved from https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/752

Arikunto, S. (2013). *Dasar-Dasar Evaluasi Pendidikan*. Bumi Aksara.

Aryani, P. R., Akhlis, I., & Subali, B. (2019). Penerapan Model Pembelajaran Inkuiri Terbimbing Berbentuk Augmented Reality pada Peserta Didik untuk Meningkatkan Minat dan Pemahaman Konsep IPA. *UPEJ Unnes Physics Education Journal*,

8(2), 90–101. Retrieved from https://journal.unnes.ac.id/sju/index.php/upej/article/view/33309

Basyir, S. N., Rustana, C. E., & Wibowo, F. C. (2020). Pengembangan Buku Pengayaan Fisika Kelautan Berbasis Augmented Reality Untuk Meningkatkan Kemampuan Berpikir Kritis. *Prosiding Seminar Nasional Fisika, 9*, 97–104. https://doi.org/10.21009/03.snf2020.02.pf.15

Cahyati, M. T., & Yohandri, Y. (2021). Efektivitas Bahan Ajar Fisika Berbasis Inquiry dengan Pendekatan CTL untuk Meningkatkan Berpikir Kreatif Peserta Didik. *Jurnal Penelitian Pembelajaran Fisika, 7*(1), 71–78. Retrieved from https://ejournal.unp.ac.id/index.php/jppf/article/view/111850

Council, N. R. (1996). National Science Education Standards. In *Kartografija i geoinformacije (Cartography and Geoinformation)*, *12*(20). https://doi.org/10.17226/4962

Ellizar, E., Hardeli, H., Beltris, S., & Suharni, R. (2018). Development of Scientific Approach Based on Discovery Learning Module. *IOP Conference Series: Materials Science and Engineering*, *335*(1). https://doi.org/10.1088/1757-899X/335/1/012101

Eva, R. P. V. B., Sumantri, M. S., & Winarsih, M. (2020). Media Pembelajaran Abad 21: Komik Digital Untuk Siswa Sekolah Dasar. *Prosiding Seminar Dan Diskusi Nasional Pendidikan Dasar 2020*, 3. Retrieved from http://journal.unj.ac.id/unj/index.php/psdpd/article/view/17744

Fakhrudin, A., Yamtinah, S., & Riyadi. (2017). International Online Journal of Primary Education. *International Online Journal of Primary Education*, *6*(2), 30–38.

Hamid, M. A., Ramadhani, R., Masrul, M., Juliana, J., Safitri, M., Munsarif, M., Jamaludin, J., & Simarmata, J. (2020). *Media pembelajaran transformatif.* Media Pembelajaran.

Herliandry, L. D., Kuswanto, H., & Hidayatulloh, W. (2021). Improve Critical Thinking Ability Through Augmented Reality Assisted Worksheets. *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)*, *541*(Isse 2020), 470–475. https://doi.org/10.2991/assehr.k.210326.067

Ilhamdi, M. L., Novita, D., & Rosyidah, A. N. K. (2020). Pengaruh Model Pembelajaran Inkuiri Terbimbing terhadap Kemampuan Berpikir Kritis IPA SD. *Jurnal KONTEKSTUAL*, *1*(2), 49–57. https://doi.org/10.46772/kontekstual.v1i02.162

Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0. *Edukatif : Jurnal Ilmu Pendidikan*, *4*(2), 3011–3024. https://doi.org/10.31004/edukatif.v4i2.2589

Iqliya, J., & Kustijono, R. (2019). Keefektifan media augmented reality untuk melatihkan keterampilan berpikir kritis siswa. *Seminar Nasional Fisika (SNF) 2019*, 19–25.

Ismail, N. A., Wahid, N. A., Yusoff, A. S. M., Wahab, N. A., Rahim, B. H. A., Majid, N. A., Din, N. M. N., Ariffin, R. M., Adnan, W. I. W., & Zakaria, A. R. (2020). The Challenges of Industrial Revolution (IR) 4.0 towards the Teacher's Self-Efficacy. *Journal of Physics: Conference Series*, *1529*(4), 0–6. https://doi.org/10.1088/1742-6596/1529/4/042062

Kemdikbud. (2019). *Risalah Kebijakan Penggunaan Gawai*. *2017*, 1–4. Retrieved from www.puslitjakdikbud.go.id

Khairunnisa, S., & Aziz, T. A. (2021). Studi Literatur: Digitalisasi Dunia Pendidikan dengan Menggunakan Teknologi Augmented Reality pada Pembelajaran Matematika. *Jurnal Riset Pendidikan Matematika Jakarta*, *3*(2), 53–62. https://doi.org/10.21009/jrpmj.v3i2.22267

Khasani, R., Ridho, S., & Subali, B. (2019). Identifikasi Kemampuan Berpikir Kritis Siswa SMP Pada Materi Hukum Newton. *Jurnal Penelitian Pendidikan IPA*, *5*(2), 165. https://doi.org/10.29303/jppipa.v5i2.192

Lewis. R. Aiken. (1985). Three Coefficients For Analyzing The Reliability And Validity Of Ratings. *Educational and Psychological Measurement*, *45*, 131–141. Retrieved from https://journals.sagepub.com/doi/abs/10.1177/0013164485451012

Mashami, R. A., Khaeruman, K., & Ahmadi, A. (2021). Pengembangan Modul Pembelajaran Kontekstual Terintegrasi Augmented Reality untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *Hydrogen: Jurnal Kependidikan Kimia, 9*(2), 67-77. https://doi.org/10.33394/hjkk.v9i2.4500

Masithah, I., Jufri, A. W., & Ramdani, A. (2022). Bahan Ajar IPA Berbasis Inkuiri Untuk Meningkatkan Literasi Sains. *Journal of Clasroom Action Research*, *4*(2), 147–151. https://doi.org/10.29303/jcar.v4i1.1758

Muakhirin, B. (2014). Peningkatan Hasil Belajar IPA Melalui Pendekatan Pembelajaran Inkuiri Pada Siswa SD. *Jurnal Ilmiah Guru Caraka Olah Pikir Edukatif*, *1*(1), 51–57. Retrieved from https://journal.uny.ac.id/index.php/cope/article/viewFile/2933/2453

Muiz, A., et. a. (2016). Implementasi Model Susan Loucks-Horsley Terhadap Communication and Collaboration Peserta Didik Smp. *Unnes Science Education Journal*, *5*(1), 1079–1084. https://doi.org/10.15294/usej.v5i1.9565

Novita, R., & Harahap, S. Z. (2020). Pengembangan Media Pembelajaran Interaktif pada Mata Pelajaran Sistem Komputer di SMK. *Jurnal Informatika*, *8*(1), 36–44. https://doi.org/10.36987/informatika.v8i1.1532

Nuzulah, D. F., Kirana, T., & Ibrahim, M. (2023). *Validity of Inquiry-Based Learning Tools on Students ' Scientific Argumentation Ability. 4*(2), 137–148.

Oktaviani, Y., Lusa, H., & Noperman, F. (2020). Pengaruh Augmented Reality sebagai Media Pembelajaran terhadap Minat Belajar Siswa Mata Pelajaran IPA SD Kota Bengkulu. *JURIDIKDAS: Jurnal Riset Pendidikan Dasar*, *2*(3), 202–208. https://doi.org/10.33369/juridikdas.2.3.202-208

Panjaitan, R. G. P., Titin, T., & Putri, N. N. (2020). Multimedia Interaktif Berbasis Game Edukasi sebagai Media Pembelajaran Materi Sistem Pernapasan di Kelas XI SMA. *Jurnal Pendidikan Sains Indonesia*, *8*(1), 141–151. https://doi.org/10.24815/jpsi.v8i1.16062

Permana, A. H., Bakri, F., & Islahana, N. (2019, December). Buku Ipa Dilengkapi Dengan Teknologi Augmented Reality: Melatih Keterampilan Berpikir Tingkat Tinggi Siswa Smp Kelas Viii Semester Genap. In *Prosiding Seminar Nasional Fisika (E-Journal), 8*, 87–94. https://doi.org/10.21009/03.snf2019.01.pe.11

Putra, R. D. Y. S., Susilaningsih, & Abidin, Z. (2020). Pengembangan Media Website E-Learning Berbasis Model Responsive Web Design untuk Siswa SMA. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *3*(3), 292–302. https://doi.org/10.17977/um038v3i32020p292

Rahayu, R., Iskandar, S., & Abidin, Y. (2022). Inovasi Pembelajaran Abad 21 dan Penerapannya di Indonesia. *Jurnal Basicedu*, *6*(2), 2099–2104. https://doi.org/10.31004/basicedu.v6i2.2082

Rahmawati, F., & Atmojo, I. R. W. (2021). Analisis Media Digital Video Pembelajaran Abad 21 Menggunakan Aplikasi Canva Pada Pembelajaran IPA. *Jurnal Basicedu*, *5*(6), 6271–6279. https://doi.org/10.31004/basicedu.v5i6.1717

Retnaningsih, D. (2019). Tantangan dan Strategi Guru di Era Revolusi Industri 4.0 dalam Meningkatkan Kualitas Pendidikan. *Prosiding Seminar Nasional: Kebijakan Dan Pengembangan Pendidikan Di Era Revolusi Industri 4.0., September*, 23–30.

Risma Agustina, Yudha Irhasyuarna, & Sauqina, S. (2022). Pengembangan Media Articulate Storyline Topik Mekanisme Pendengaran Manusia Dan Hewan Untuk Peserta Didik SMP. *JUPEIS : Jurnal Pendidikan Dan Ilmu Sosial*, *1*(3), 81–89. https://doi.org/10.55784/jupeis.vol1.iss3.119

Ritonga, N., Gultom, H. S. B., & Nazliah, R. (2020). Kemampuan Berpikir Kritis dalam Proses Pembelajaran IPA melalui Pendekatan Keterampilan. *Jurnal Pendidikan Sains Dan Aplikasinya (JPSA)*, *3*(2), 41–55. https://doi.org/10.31004/basicedu.v4i3.401

Rizki, C., & Setyarsih, W. (2022). Identifikasi Miskonsepsi Siswa dan Penyebabnya pada Materi Elastisitas Menggunakan Three–Tier Diagnostic Tes. *Inovasi Pendidikan Fisika*, *11*(3), 32–43.

Setyawan, B., Rufii, Nf., & Fatirul, A. N. (2019). Augmented Reality Dalam Pembelajaran Ipa Bagi Siswa Sd. *Kwangsan: Jurnal Teknologi Pendidikan*, *7*(1), 78–90. https://doi.org/10.31800/jtp.kw.v7n1.p78--90

Sharma, P. (2019). Digital Revolution of Education 4.0. *International Journal of Engineering and Advanced Technology*, *9*(2), 3558–3564. https://doi.org/10.35940/ijeat.a1293.129219

Siahaan, A. D., Medriati, R., & Risdianto, E. (2019). Pengembangan Penuntun Praktikum Fisika Dasar Ii Menggunakan Teknologi Augmented Reality Pada Materi Rangkaian Listrik Dan Optik Geometris. *Jurnal Kumparan Fisika*, *2*(2), 91–98. https://doi.org/10.33369/jkf.2.2.91-98

Syamsul, H., & Novaliyosi. (2019). TIMSS Indonesia (Trends in International Mathematics and Science Study). *Prosiding Seminar Nasional & Call For Papers Program Studi Magister Pendidikan Matematika Universitas Siliwangi*, 108–108. https://doi.org/10.1007/978-94-6209-497-0_97

Syofyan, H., & Halim, A. (2017). Peningkatan Kemampuan berpikir Kritis Siswa Dalam Pembelajaran IPA Melalui Metode Problem Solving. *Jurnal Forum Ilmiah*, *14*(1), 49–64. Retrieved from https://ejurnal.esaunggul.ac.id/index.php/Form il/article/view/1731

Trianto. (2010). *Model Pembelajaran Terpadu, Konsep, Strategi dan Implementasinya dalam KTSP*. Bumi Aksara.