



Development of Interactive LKPD Based on Augmented Reality Media on Chemical Equilibrium Material

Dira Khairunisa*, Intan Juwita*, Adhitya Shahrian Putra, Juwita Marine Egya, Alfina, Kurnia Wati Br Bangun, Zainuddin Muchtar

Departement Chemistry Education, Faculty of Mathematics and Natural Sciences,
Medan State University,
Jl. William Iskandar Pasar V, Medan, Indonesia.

*Corresponding e-mail: intanmiss078@gmail.com dirakhairunisa03@gmail.com

Received: November 30th, 2024 Accepted: December 3rd, 2024 Online Published: December 26th, 2024

Abstract : Development of Interactive LKPD Based on Augmented Reality Media on Chemical Equilibrium Material. The development of technology in the world of education is a demand for the curriculum, so currently technology is developing, namely Augmented Reality, which allows its use to interact in a real way with the system. The application of Augmented Reality can be a solution to educational problems that require the application of science and technology in every subject, especially chemistry in chemical equilibrium material. Augmented Reality-based LKPD was developed based on validation results, teacher and student responses. The development method used is the research and development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. The data collection techniques used were teacher interviews, analysis of student needs, media and material validation sheets and student response questionnaires. Based on validation carried out on interactive LKPD based on Augmented Reality on chemical equilibrium material, the level of validation by media expert validators was 95% with the criteria "very feasible". And a response test was carried out on students, obtaining a percentage of 76% with the "interesting" criteria. So it can be concluded that overall the interactive LKPD product based on augmented reality media on chemical equilibrium material that has been developed is interesting for students to study for use in the learning process, especially on chemical equilibrium material.

Keywords: LKPD, Augmented Reality, Chemical Equilibrium

Abstrak : Pengembangan LKPD Interaktif Berbasis Media Augmented Reality pada Materi Keseimbangan Kimia. Perkembangan teknologi di dunia pendidikan merupakan tuntutan kurikulum, sehingga saat ini berkembang teknologi yaitu Augmented Reality yang mengijinkan penggunaannya untuk berinteraksi secara nyata dengan sistem. Penerapan Augmented Reality ini dapat menjadi solusi permasalahan pendidikan yang menuntut penerapan IPTEK dalam setiap mata pelajaran khususnya kimia pada materi keseimbangan kimia. LKPD berbasis Augmented Reality dikembangkan berdasarkan hasil validasi, respon guru dan siswa. Metode pengembangan yang dilakukan adalah metode research and development (R&D) dengan

model pengembangan ADDIE(Analisis, Design, Development, Implementation, and Evaluation). Teknik pengumpulan data yang digunakan wawancara guru, analisis kebutuhan peserta didik, lembar validasi media dan materi serta angket respon siswa. Berdasarkan validasi yang dilakukan pada LKPD interaktif berbasis Augmented Reality pada materi kesetimbangan kimia diperoleh tingkat validasi oleh validator ahli media adalah sebesar 95% dengan kriteria “sangat layak”. Dan dilakukan uji respon kepada siswa diperoleh persentase sebesar 76% dengan kriteria “menarik”. Maka dapat disimpulkan bahwa secara keseluruhan produk LKPD interaktif berbasis media augmented reality pada materi kesetimbangan kimia yang telah dikembangkan menarik untuk dipelajari siswa untuk digunakan dalam proses pembelajaran khususnya pada materi kesetimbangan kimia.

Kata kunci: LKPD, Augmented Reality, Kesetimbangan Kimia

▪ INTRODUCTION

The era of globalization or the 21st century shows a fundamental transformation in lifestyle compared to previous times. This transformation has a significant impact on various areas of life, including education. One of the striking changes is technological advances which continue to develop rapidly in the learning context. These technological developments affect important aspects of life, such as ways of communicating, collaborating, learning processes, and of course teaching methods (Harahap & Nugroho, 2022). As time goes by, science and technology continue to develop rapidly. In this context, advances in information technology have a significant impact on educational activities, creating meaningful changes and improvements (Septarini & Kholiq, 2021).

Learning media is very closely related to technology. The development of learning media goes hand in hand with technological developments that occur. From the beginning the learning process only involved writing and listening, until the learning process used smartphones, laptops, and even the digital world. One technology that has recently been applied in the field of education, especially learning media, is augmented reality (Saca, 2021). Augmented Reality (AR) is a technology that combines elements from the physical environment with virtual or computer elements. The goal is to create an experience where the physical and digital worlds merge, allowing users to observe and interact with virtual objects or additional information that appears on top of real reality (Kartini et al., 2023).

Augmented Reality has the potential as a learning tool to increase attractiveness and clarity in the learning process. Augmented Reality technology allows users to shift the position of the displayed model, allowing them to view it from various angles. Involving students in these kinds of activities can improve their understanding of the subject matter. (Ismayani, 2020). Apart from that, the use of Augmented Reality technology in the learning context is also in line with the evolution of Society 5.0 which emphasizes the use of technology to achieve a human-centered society. In the Society 5.0 concept, education is focused on developing individual potential and empowering students to be able to become innovators, creative, and have the ability to adapt to technological changes (Rahayu, 2021).

With the development of a generation that is so complex, the ability to adapt to the use of the latest technological advances is very high. The use of information technology in learning can be an appropriate method. These student characteristics are

one of the considerations in selecting the learning media to be used. Technological developments are increasingly advanced, making learning media more interesting and more concise, although it does not reduce the essence of the material. One of the developments in learning media that is currently still new is Augmented Reality-based learning media. Through Augmented Reality media, students can interact directly and see virtual objects in a real environment. They can manipulate molecular structures, see reaction animations or find out more about molecules in detail and invite students to be actively involved in learning (Sulistianingsih, 2022).

Chemistry is considered a challenging subject because students often have difficulty understanding abstract concepts which causes them to understand different ideas (Musengimana et al., 2021). Students' difficulty in understanding chemistry learning is because chemistry is an abstract and complex concept so it requires in-depth understanding to learn it (Sariati et al., 2020).

Chemical equilibrium is a material that is difficult for students to understand because most of the concepts are abstract. There are several factors that cause chemical equilibrium to be difficult, including having abstract concepts, difficulty understanding terms because students only memorize them, but do not properly understand the meaning of the terms in chemical equilibrium material (Marfu'a& Astuti, 2022).

The learning process that uses media can make previously abstract material easier for students to understand (Noviyanti et al., 2023). Chemical equilibrium is a reaction that takes place continuously. With Augmented Reality media, students can directly see the reaction process taking place, such as color changes, particle movement, or chemical reactions occurring around them. This allows students to describe concepts more clearly and strengthen their understanding. Utilizing chemical equilibrium material in Augmented Reality can provide an in-depth learning experience. Students can explore concepts in more detail, observe reactions realistically, and relate them to real-world phenomena. By doing this, they can increase their understanding and be able to apply chemical equilibrium concepts in a variety of contexts. The development of interactive learning media based on Augmented Reality on chemical equilibrium material can be an effective tool for improving chemistry learning. By presenting the concept of equilibrium visually, interactively, and in depth, Augmented Reality can help students understand and master the material better.

To overcome these problems, it is necessary to expand the development of technology-based learning media to facilitate the learning process in the era of Society 5.0 evolution. Research conducted by ((Bakri et al., 2019) has created Student Worksheets (LKPD) as an exercise to improve higher level thinking skills 4 in high school. The results of the research show that LKPD equipped with videos via Augmented Reality are effectively used in learning to developing high-level thinking skills in class Unity, Blender 3D, and Canva media were created to function as interactive worksheets based on augmented reality media which were developed interactively using the AR-Chemical Equilibrium application which was considered feasible, effective and effective and received positive responses from students

▪ **METHOD**

This research is included in the type of research and development (Research and Development). The development model used in this research is the ADDIE development model. The ADDIE development model is an abbreviation of Analysis, Design, Development, Implementation and Evaluation. According to the product

development steps, this development research model is more rational and more complete. This model can be used for various forms of product development such as models, learning strategies, learning methods, media and teaching materials (Nababan, 2020). However, in this research, the development steps were limited to four stages according to the specific development conditions. This research will be carried out at the Madrasah Aliyah Swasta (MAS) Proyek Univa Medan school located on Jalan Sisingamangaraja Km 5.5 No.10, Medan Amplas District, Medan City, North Sumatra. Sampling used a purposive sampling technique, namely directly selecting one class, namely XI MIA 2 as a sample.

The procedural stage in this research is the first stage of analysis. The analysis was carried out in several stages, namely needs analysis which was carried out by interviewing teachers and distributing student needs analysis questionnaires, curriculum analysis, and student characteristics analysis. The second stage is design, at this stage material studies and product design for interactive chemical equilibrium worksheets and augmented reality media are carried out. The third stage is development, at this stage the interactive LKPD learning media based on Augmented Reality is created on chemical equilibrium material according to the design that has been prepared previously. Then at this stage a product feasibility test is also carried out before implementation. The fourth and final stage is implementation, where the augmented reality-based interactive LKPD that has been developed is tested on teachers and students.

▪ RESULT AND DISCUSSION

Interactive LKPD based on Augmented Reality developed with the ADDIE model has 5 stages such as analyze, design, development, implementation, and evaluation, but the development carried out is limited to the fourth stage, namely the implementation stage.

The first stage is the analysis stage. At this analysis stage, an initial condition analysis is carried out which aims to provide an overview and guideline in developing products to suit the needs of the school. Based on the initial analysis, it was carried out by conducting interviews with chemistry teachers and distributing questionnaires to students. The results of interviews with chemistry teachers showed that learning in schools uses the K13 curriculum type. Therefore, teachers expect the development of innovative learning media that facilitate students in the learning process. In addition, the results obtained based on the distribution of student needs questionnaires can be seen in table 1.

Table 1. Analysis of student needs

	Questions	Answer choices	%
1.	In my opinion, learning chemistry in class	Enjoyable	95.2%
		Boring	4.8%
2.	Explanation of chemical equilibrium material by teachers in chemistry learning	Easy for undertood	85.7%
		Difficult to understand	14.3%
3.	In studying the material on chemical equilibrium, I feel ... in study it.	Easy	61.9%
		Difficult	38.1%
4.	In my opinion, the chemical equilibrium material in chemistry learning is in the book	Easy for undertood	71.4%
		Difficult to	28.6%

		understand	
5.	What learning media do teachers use when explaining chemical equilibrium material in chemistry learning	Books	90.5%
		Video	4.8%
		Powerpoint	4.8%
6.	In my opinion, the learning media used by teachers to explain the chemical equilibrium material in chemistry learning	Interesting and easy to understand	81%
		Interesting and difficult to understand	14.3%
		Less interesting and difficult to understand	4.8%
7.	Does your little brother enjoy learning using learning media	Happy	95.2%
		Not happy	4.8%
8.	I think it's more fun to learn using	Books	76.2%
		Mobile phone	23.8%
9.	Learning media that displays images (visuals) will ... I understand the abstract material on chemical equilibrium	Make it easier	100%
		Make it difficult	0%
10.	Have you ever heard of media? Augmented Reality	Ever	66.7%
		Never	33.3%
11.	Whether younger brother interested if study use media learning based on Augmented Reality	Interested	95.2%
		Not interested	4.8%
12.	Use of media Augmented Reality made me ... in studying the material of chemical equilibrium	Motivated	85.7%
		Not motivated	14.3%

Based on the results of the needs analysis questionnaire presented, it can be seen that most students of class XIMIA 2 have studied chemical equilibrium material and have difficulty in learning it because of the difficulty in imagining abstract chemical equilibrium material. From these problems, it is hoped that there will be interesting learning media that facilitates and increases students' learning motivation. One type of learning media that can be used for this is using augmented reality. The use of augmented reality in learning and teaching will be more effective and have a better impact than conventional methods (Ali et al., 2023).

After analyzing student needs, the next step is to identify student characteristics. It was found that 1) most students prefer to learn using mobile phones, 2) students find it easier to understand the material if it is taught using visual media. The use of smartphones not only functions as a means of communication, but can also be used as a learning medium (Kusuma, 2018). After identifying student characteristics, researchers made a development by collaborating technology with printed teaching materials, namely interactive LKPD which can be run using a mobile phone through the application developed, namely AR Chemical Equilibrium. With this development, it is in accordance with the character of students where as many as 76.2% of students prefer to learn using mobile phones and as many as 23.8% of students prefer to use printed books.

The second stage is the design stage. In this stage the researcher takes several steps, such as reviewing the material and designing the product. In this design process several activities are carried out, namely 1) analyzing the syllabus containing KI, KD,

indicators, learning objectives and learning materials in accordance with the 2013 curriculum with the teaching material being chemical equilibrium in AR-based interactive LKPD, 2) designing the AR-Chemical Equilibrium application product, and 3) coding using visual studio 2016 to make it into an application.

The third stage is the development stage. This stage is the development of augmented reality-based learning media. The activities carried out are material assessment and product design in the form of interactive LKPD using the discovery learning model and arranged based on the stages of syntax from the discovery learning model. The stages of the discovery learning model are stimulus, problem identification, data collection, data processing, verification or proof and generalization or drawing conclusions. AR-based interactive media is made to run the developed interactive LKPD which is arranged and adjusted to the examples in the LKPD and packaged in the form of an application called AR-Chemical Equilibrium.

The interactive student worksheet (LKPD) based on augmented reality media that has been developed was then validated by media experts and material experts with expert validators, namely lecturers from the chemistry department of Medan State University. The results of the validation can be seen in the table.

Table 2. Material Validation Results

Validation Aspects	Average (%)	Criteria
1. Curriculum	100%	Very worthy
2. Quality content/ material	93.75%	Very worthy
3. Linguistic	100%	Very worthy
Amount	96.15%	Very worthy

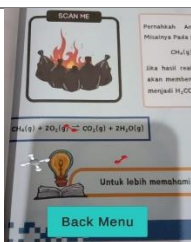
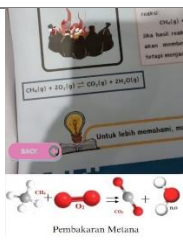
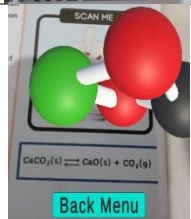
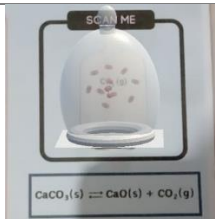
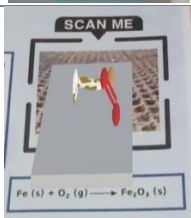

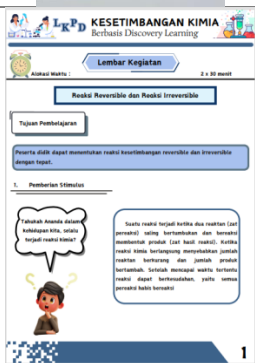

Table 3. Media Validation Results

Validation Aspects	Average (%)	Criteria
1. Learning	95%	Very worthy
2. Media	95%	Very worthy
3. Design	95%	Very worthy
Amount	95%	Very worthy

The percentage is obtained from the total percentage (%) of all aspects divided by the number of aspects and obtains a total average percentage of 95% with the criteria of "very feasible". This is also accompanied by suggestions and input from the media expert validator. Based on the validation of the results carried out by the media expert validator, the criteria for "very feasible" were obtained, namely AR-based interactive LKPD on the chemical equilibrium material that had been developed.

Developments carried out based on suggestions for improvement from validators obtained from the media are shown in the table 4.

Table 4. Validators Improvement Suggestions

Suggestions	Before Revision	After Revision
3D models do not is right on the marker when scanned		
Adding effects container on object		
Iron rusting incident invisible		
Fetching video stimulus		

The fourth stage in the ADDIE development model and the final stage in this study is implementation. The researcher conducted a test of teacher and student responses to the interactive LKPD based on Augmented Reality media that had been developed. The response test was conducted at the MAS Project Univa Medan. The steps in the implementation stage in this study include: trials on teachers, and trials on students.

Interactive LKPD based on augmented reality media that has been created through a development process and validation by expert validators is then tested on teachers. This limited test was conducted to determine the teacher's response to the LKPD that has been developed. The results of the average percentage of teacher response tests can be seen in the table 5.

There are several aspects assessed in the teacher response test, including achievement of competencies and learning objectives, student responses, level of difficulty in implementation, and time adequacy. This is shown in table 5.

Table 5. Teacher Respond Results

Validation Aspects	Average (%)	Criteria
1. Competency achievement and leaning objects	75%	Good
2. Student response	75%	Good
3. Level of difficulty in implementing	88%	Very good
4. Time sufficiency	50%	Pretty good
Amount	72%	Good

Next, a response test is conducted on students. The response test on students is conducted by the researcher being present directly in the class and then providing information related to the research that the researcher is conducting and directing students to view, read, study, and use interactive LKPD based on augmented reality media which the learning media can be accessed by students via their respective smartphones. The aspects assessed in the response test on students include the appearance aspect, the language aspect, the ease aspect, and the usefulness aspect. This is shown in table 6.

Table 6. Students Respond Results

Validation Aspects	Average (%)	Criteria
1. Appearance	80%	Good
2. Linguistic	70%	Good
3. Easy of use	71%	Good
4. Benefits	83%	Very good
Amount	76%	Good

The results obtained in the trial conducted on students of class XI MIA 2 are ". Augmented reality learning media helps the learning process because there is a 3D augmented reality model in it because the existing 3D model is made to attract users as if users can interact directly with the 3D object. In the implementation stage when students look enthusiastic in using learning media, this can support the percentage of student satisfaction that researchers get because if referring to the statement (Harmen et al., 2019) students will feel satisfied when the learning media used is in accordance with their expectations. Students' interest in learning media is based on how interesting and appropriate the learning media is with what students want (Harmen et al., 2019).

Based on research conducted by (Ramadani, et al, 2020), it is known that the interactive media developed obtained an average assessment score at the field trial stage of 33 students in class .00 from the ideal score of 100 with class completion of 82%; (3) the responses of student and teacher respondents for the learning modules developed also received high and very high scores in the respective categories with percentages of 80.38% and 100% so that the modules were said to be practical. So the conclusion is that the augmented reality-based chemistry learning module that has been developed with a 4D model is valid, practical and effective for use in learning. This shows that the developed Augmented Reality-based interactive media can be used as a learning resource in learning.

Research conducted by (Fitriyana & Purwasi 2020), namely discovery learning-based learning. The worksheets developed in this research are categorized as valid, practical and effective for use as learning media. Based on the description of the data

obtained, the final worksheet product based on discovery learning on the material of surface area and volume of cubes and blocks was declared valid, practical and effective so that it could be used as a learning resource for students in understanding the material of surface area and volume of geometric shapes. And research conducted by (Rosilawati et al, 2024) shows that LKPD based on chemical representation with the Discovery Learning model is effectively used to improve student learning outcomes in material on factors that influence shifts in the direction of chemical equilibrium, this is shown in the increase in n-gain which is significant between the two components, namely the experimental class and the control class

▪ CONCLUSION

Based on the research that has been conducted, it can be concluded that the level of feasibility of developing interactive LKPD based on augmented reality media on chemical equilibrium material based on BSNP standards that have been validated by media experts with a total average percentage value obtained from media experts of 95% with the criteria "very feasible". So overall, interactive LKPD based on augmented reality media on chemical equilibrium material that has been developed is feasible to be used in the learning process, especially on chemical equilibrium material. and student assessment of the attractiveness of interactive LKPD based on augmented reality media on chemical equilibrium material that has been developed obtained an average percentage of 76% with the criteria "interesting". So it can be concluded that overall, interactive LKPD products based on augmented reality media on chemical equilibrium material that have been developed are interesting for students to learn to be used in the learning process, especially on chemical equilibrium material

▪ REFERENCES

- Ali, D. F., Johari, N., & Ahmad, A. R. (2023). The effect of augmented reality mobile learning in microeconomic course. *International Journal of Evaluation and Research in Education*, 12(2), 859–866.
- Bakri, F., Sumardani, D., & Mulyati, D. (2019). Integrating augmented reality into worksheets: Unveil learning to support higher-order thinking skills. *AIP Conference Proceedings*, 2169(1), 1–8. <https://doi.org/10.1063/1.5132647>
- Fitriyana, N., & Purwasi, L. A. (2020). Pengembangan Lembar Kerja Siswa Berbasis Discovery Learning. *Jurnal Pendidikan Matematika : Judika Education*, 8(75), 147–154. <https://doi.org/10.1016/j.jnc.2020.125798>
- Harahap, L. K., & Nugroho, D. E. (2022). Pengembangan Media Pembelajaran Mobile Learning Terintegrasi Augmented Reality dan Unity of Sciences Materi Stoikiometri. *Journal of The Indonesian Society of Integrated Chemistry*, 14(1), 21–27. <https://doi.org/10.22437/jisic.v14i1.15962>
- Harmen, H., Agustini, F., & Aprinawati, A. (2019). Analisis Tingkat Kepuasan Mahasiswa Terhadap Metode Dan Media Pembelajaran Pada Mata Kuliah Manajemen Sumberdaya Manusia Semester 2 Kelas a Di Jurusan Manajemen. *Niagawan*, 8(1), 50. <https://doi.org/10.24114/niaga.v8i1.12806>
- Ismayani, A. (2020). *Membuat Sendiri Aplikasi Augmented Reality* (1st ed.). Elix Media Komputindo.
- Kartini, K. S., Tri, I. N., Putra, A., Lukman, N. H., Wiryana, G., Indonesia, T.,

- Informatika, T., Bisnis, I., & Informatika, T. (2023). Pengembangan Media Pembelajaran Berbasis Augmented Reality pada Materi Molekul Kimia Berbasis Android Tingkat SMA. *E-Tech*, 11(01), 1–5.
- Kusuma, S. D. Y. (2018). Perancangan Aplikasi Augmented Reality Pembelajaran Tata Surya Dengan Menggunakan Marker Based Tracking. *Jurnal Informatika Universitas Pamulang*, 33(1), 33–38.
- Marfu'a, S., & Astuti, R. T. (2022). Analisis Kesulitan Belajar Siswa Dalam Memahami Materi Keseimbangan Kimia. *Prosiding Seminar Nasional Pendidikan Kimia 2022*, 1(1), 297–307.
- Musengimana, J., Kampire, E., & Ntawiha, P. (2021). Factors Affecting Secondary Schools Students' Attitudes toward Learning Chemistry: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(1), 1–12. <https://doi.org/10.29333/ejmste/9379>
- Nababan, N. (2020). Pengembangan Media Pembelajaran Berbasis Geogebra Dengan Model Pengembangan Addie Di Kelas XI SMAN 3 Medan. *Jurnal Inspiratif*, 6(1), 37–50.
- Nisa, V. C., Sari, D. N., Wiyati, A., & Rahinawati, Y. (2023). Jurnal Pendidikan dan Pembelajaran Kimia Supporting the Digital Era Through the Application of Discovery Learning with the TPACK Framework Assisted to Improve Student Learning Outcomes and Interests Varradiah Choirun Nisa et al , Supporting the Digital Er. *Jurnal Pendidikan Dan Pembelajaran Kimia*, 12(3), 14–27.
- Noviyanti, S., Sofwan, M., & Widyawati, A. D. (2023). the Importance of Learning Media To Increase Students'Interest in Learning in Study Primary School Ips Learning. *Jurnal* 12(4), 1889–1893.
- Rahayu, K. N. S. (2021). Sinergi pendidikan menyongsong masa depan indonesia di era society 5.0. *Edukasi: Jurnal Pendidikan Dasar*, 2(1), 87–100.
- Ramadani, R., Ramlawati, R., & Arsyad, M. (2020). Perkembangan Augmented Reality Modul Pembelajaran Kimia Berbasis Komputer. *Kajian Pendidikan Kimia* 3(2), 152-162.
- Rosilawati, I., Riyanti, M. D., & Kadaritna, N. (2024). Effectiveness of LKPD Based on Chemical Representation Using the Discovery Learning Model in Improving Science Process Skills On Chemical Equilibrium Material. *Jurnal Pendidikan Dan Pembelajaran Kimia*, 13(1), 123–132.
- Saca, A. (2021). Penerapan Marker-Based Augmented Reality Sebagai Media Pembelajaran Tata Surya. *JIKA (Jurnal Informatika)*, 5(1), 33. <https://doi.org/10.31000/jika.v5i1.3560>
- Sariati, N. K., Suardana, I. N., & Wiratini, N. M. (2020). Analisis Kesulitan Belajar Kimia Siswa Kelas Xi Pada Materi Larutan Penyangga. *Jurnal Imiah Pendidikan Dan Pembelajaran P-ISSN : 1858-4543 e-ISSN : 2615-6091*, 4(April 2020), 1–12.
- Septarini, R. A., & Kholiq, A. (2021). Pengembangan Media Prest Untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik SMA Pada Materi Momentum Dan Impuls. *IPF: Inovasi Pendidikan Fisika*, 10(1), 32–38. <https://doi.org/10.26740/ipf.v10n1.p32-38>

Sulistianingsih, A. . D. K. (2022). Potensi Penggunaan Teknologi Augmented Reality (AR) dan Virtual Reality (VR) dalam Pembelajaran Sejarah Arsitektur di Era Pandemi Covid-19. *JUPITER (Jurnal Pendidikan Teknik Elektro)*, 07(01), 10–18. <http://e-journal.unipma.ac.id/index.php/JUPITER/article/view/12262/4091>