Physics Communication
Volume 9 Issue 1 Year 2025 Pages 53-61

P-ISSN 2528-5971 | E-ISSN 2528-598X
https://journal.unnes.ac.id/journals/pc
https://doi.org/10.15294/pc.v9i1.8268

Development of Website-Based Teaching Materials with a Multi-Representation Approach Assisted by *Scratch* Simulation in Circular Motion

Yulita Nurbaiti, Wahyu Hardyanto, Suharto Linuwih

Master of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia

*Correspondence to: *nurbaitiyulita5@gmail.com*

Abstract: This study is an R&D research that aims to describe the feasibility and characteristics of website-based teaching materials with a multi-representation approach assisted by *Scratch* simulation in a circular motion. The development model used in this study was a 4-D development model, (define, design, develop, disseminate). The define stage consists of the draft instrument, learning objectives flow (ATP), analysis and learning modules, and analysis journal. The design stage consists of teaching materials design and instrument expert validation design for evaluating the teaching materials. The development stage consists of developing instruments for assessing the digital teaching, teaching materials prototype, and expert validation and revisions based on the results of expert validation. The dissemination stage consists of the final validation consisting of the results of the final validation of the product and the dissemination of teaching materials through the publication of scientific papers in journals. Based on the results of expert validation, the percentage of average of score on the material aspect is 91.25% with a very feasible category. The percentage of an average score on the media aspect is 92.82% with the very feasible category. The readability percentage of teaching materials has an average value of 87.59% in the easy-to-understand category. The percentage of teacher and student responses was 97.50% and 88.61% in the very good category response.

Keywords: Teaching Materials, Website, Multi-Representation, *Scratch*, Circular Motion

Submitted: 2024-11-1. **Revised**: 2025-02-9. **Accepted**: 2025-02-19.

Introduction

The development of science and technology in the 21st century is very rapid, bringing us to the Industrial Revolution 4.0. This revolution was marked by the emergence of advanced technology. As time goes by, it has an impact on all aspects of life, one of which is in the field of education. This is a challenge for education to improve in facing the rapid development of science and technology which demands an increase in human resources who have 21st century skills. 21st-century learning skills or 4C skills include critical thinking, communication, collaboration, and creativity (Ramadayanty *et al*., 2021). The first step is to improve human resources through improving the quality of good education.

In the 21st century, teachers are needed who can teach concepts in a student-centered manner and use an interactive approach the following technology (Kapucu *et al*., 2014). Skills The skills possessed by students are the result of culture and learning at school, where students have a perspective regarding the ideal learning model according to the subject in the learning model or approach implemented by the teacher according to their time (Häkkinen *et al*., 2017). Knowledge and skills must be followed by the formation of attitudes and behaviors that remain based on Indonesian culture.

21st-century learning has demands, namely the integration of technology as a learning medium to develop students' learning skills. Technology in the world of education has a big influence and vice versa (Gardner, 1992). Research conducted by Tambade & Wagh (2011) shows that using computers in learning is more effective than using conventional learning in physics. Computers are one of the technological developments that can create changes in increasing creativity and problem-solving skills (Barr & Stephenson, 2011). The use of digital technology is multimedia teaching materials that are presented digitally on computers/laptops or smartphones. One form of teaching material is digital teaching material used in

learning.

Physics is a branch of natural science that studies natural phenomena that are concrete and can be proven mathematically (Saputra *et al*., 2020). However, the fact is that physics learning in class tends to just provide material and does not involve students actively in learning. Physics learning is more effective if students are actively involved, especially in thinking and relating the material to phenomena in the real world which are presented contextually so that students can understand physics concepts.

Based on the results of a preliminary study in the form of interviews and observations at SMA Negeri 1 Jekulo, information was obtained that the teaching materials used were printed teaching materials. Teachers encounter difficulties explaining physics material that needs to be visualized because current teaching materials in schools are printed teaching materials that only present conceptual texts, materials, example questions, and practice questions in text form. Students' physics learning tends to be passive and students have less critical thinking skills because the tasks given by the teacher have not significantly trained critical thinking skills. Learning in the 21st century requires teaching materials that can support students to take advantage of advances in information technology and can be accessed freely without time and space limitations (Habellia & Suyanta, 2019).

Less variety in the delivery of physics material causes students to get bored and not be interested in studying physics, which is considered difficult. This shows that the learning approaches, methods, and media have not been effective in improving students' critical thinking skills and understanding of concepts. Therefore, there needs to be other learning approaches and media as alternative strategies that can be used to overcome these problems to attract students' interest in learning physics.

The use of technology and information in education can be used in Physics subjects, namely in terms of displaying microscopic study objects that cannot be reached by the human senses (Al Asy' Ari *et al*., 2021). Multiple representations play an important role in improving learning outcomes, cognitive abilities, and problem-solving. This means that the use of multi-representational teaching materials can be an alternative for increasing the competence of physics teachers in Indonesia through training (Mulhayatiah *et al*., 2022).

An alternative that can be done is to use digital teaching materials so that they are practical for students and teachers and can be accessed via smartphone or laptop. Website-based teaching materials with a multi-representation approach. When studying physics, students are required to master various types of representation simultaneously (Ramadayanty *et al*., 2021). Representation can also help someone redefine a problem in their own words by combining symbolic, graphic, verbal, and numerical representations (Alighiri *et al*., 2018).

Most students view pictorial representations and mathematical equations as opposite and dominant, and most students use one of the two to express processes that occur in reality (Kohl *et al*., 2007, 2008). However, it is known that in physics many abstract physics concepts require more effective communication from various representations, such as graphs or images.

More applications offer easy ways to create simulations. The use of simulations in physics learning is very effective for explaining concepts and increasing students' conceptual understanding (Intana *et al*., 2018). One application that can help display several representations in physics is *Scratch* software which can visualize physics material in the form of videos, simulations, and images.

Apart from that, implementing the Merdeka curriculum requires students to be actively involved in learning. In line with the multi-representation learning model which involves students actively in learning (Sunyono, 2015). One learning approach that can actively involve students is the multi-representation approach which is expected to bridge the process of students' understanding of physics concepts so that it can improve students' learning outcomes and critical thinking (Shavira et al., 2019).

Ainsworth (1999) states that multiple representations are essential to understanding scientific concepts and methods. Apart from that, Ainsworth (2006) stated that students' learning styles can be met with teaching materials using a multi-representational approach that supports students' learning to understand a concept. According to Permadi & Setyaningsih (2017) using a multi-representation approach module can improve critical thinking skills. Apart from that, Adegoke (2011) it was stated that multimedia can

improve student learning outcomes.

Much research has been conducted on website-based digital teaching materials to improve students' critical thinking skills and students' ability to understand concepts. However, there has been no research on website-based digital physics teaching materials with a multi-representation approach assisted by *Scratch* in learning physics in certain chapters.

Based on the background that has been described, research was carried out on the development of website-based digital physics teaching materials using a multi-representation approach assisted by *Scratch* to improve conceptual understanding and critical thinking for high school students. Development and application of digital teaching materials as an effort to overcome the limitations of printed teaching materials. In addition, presenting material using website-based digital physics teaching materials with a multi-representation approach assisted by *Scratch* helps students develop conceptual understanding and critical thinking.

Methods

R&D research to produce a certain product so that it can test the product's effectiveness (Sugiyono, 2019). The research adopted the 4-D development model by (Thiagarajan *et al*., 1974). The research stages include define, design, develop, and disseminate.

The subjects in this study were students of class XI-F at SMA Negeri 1 Jekulo Kudus. Data collection techniques in this research were observation, test instruments, and questionnaires. The first stage, the define stage aims to determine and apply the learning conditions and limitations of the material being developed. The define stage consists of 5 steps, namely front-end analysis, student analysis, task analysis, concept analysis, and goal specification.

The second stage, the design stage aims to design teaching material components and prepare test instruments. The design stage consists of 4 steps, namely preparing teaching materials, selecting media, selecting formats, and initial design. The development format was chosen in the form of website-based teaching materials with a multi-representation approach assisted by *Scratch* on circular motion material in the form of a website designed using the WordPress CMS application through the paid domain provider Niagahoster. The preparation of test instruments is used to measure students' ability to understand concepts and think critically.

The third stage, the develop stage aims to produce website-based teaching materials with a valid *Scratch*-assisted multi-representation approach. At this stage, teaching materials developed by experts are assessed and development tests are carried out.

The fourth stage of dissemination, the development of teaching materials reaches the final stage when the results of development trials show consistent achievements and expert assessments produce positive comments (Thiagarajan *et al*., 1974). The stage of disseminating teaching materials is carried out through journal publications.

The instrument used was a material and media validation sheet questionnaire which was developed using a Likert scale according to (Sugiyono, 2015). The data analysis technique used in this research is to determine the characteristics, suitability of teaching materials, readability, and teacher and student responses which are shown in Table 1. Meanwhile, to determine the percentage of suitability level according to Sudijono Anas (2014) it is calculated using the following formula equation.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

After getting the score percentage using the formula equation, the score percentage obtained can be seen in Table 1.

Table 1. Eligibility Level Criteria

Feasible Percentage (%)	Criteria
$85{,}00 < P \leq 100{,}00$	Very feasible
$70{,}00 < P \leq 85{,}00$	Feasible
$50{,}00 < P \leq 70{,}00$	Quite feasible
$1{,}00 < P \leq 50{,}00$	Not feasible

The teaching materials developed are appropriate and fulfill the classification, valid and quite valid

with a percentage of ≥ 51%. The learning response is positive if the number of students and teachers in the positive category is ≥ 50% of all students (Setyandaru *et al*., 2017).

.

Results and Discussion

Results

This research is development research to produce a product in the form of teaching materials, testing validity, describing the characteristics, feasibility, readability, and response of teachers and students to the product. The product resulting from the development of physics learning is aimed at class XI-F students at SMA 1 Jekulo Kudus.

The product resulting from development research in this research is website-based teaching materials with a multi-representation approach assisted by *Scratch* on circular motion material. This teaching material was developed referring to the Merdeka curriculum based on learning outcomes which are outlined in the learning objectives and teaching modules. The digital teaching materials developed are focused on improving high school student's ability to understand concepts and think critically. The study of physics material in this digital teaching material is circular motion material at the high school level, class XI-F.

The characteristics of the digital teaching materials developed are, 1) website-based digital teaching materials presented in the form of a website using electronic devices owned by students, 2) digital teaching materials with a multi-representation approach assisted by *Scratch* presenting circular motion material with various representations in written form, images, equations, simulations in the form of *Scratch* simulations equipped with student worksheets to train critical thinking skills, 3) teaching materials equipped with practice questions and answer keys designed to train students' conceptual understanding abilities, 4) digital teaching materials utilizing electronic technology to reduce the use of paper on printed teaching materials, 5) teaching materials can be stored on teachers' and students' electronic devices so they can be accessed anytime and anywhere, and 6) teaching materials with evaluation questions designed to measure the ability to understand concepts and think critically.

The feasibility of website-based teaching materials with a multi-representation approach assisted by *Scratch* was using a validation questionnaire by material experts and media experts. Material experts assess the suitability of theories, concepts, and questions presented in teaching materials, while media experts assess the suitability of media from the aspect of digital teaching materials (Opra A. *et al*., 2013). Material and media experts consist of 2 expert lecturers and 2 physics teachers at SMA N 1 Jekulo Kudus. Analysis of validation results using content validity is determined through Aiken's validity. The results of the feasibility assessment of digital teaching materials developed in this research by material experts are in Table 2.

Table 2. Assessment of the Feasibility of Teaching Materials by Material Experts

Validator Code	Total Score	Maximum Score	Percentage (%)	Criteria
V-01	70	80	87.50	Very feasible
V-02	66		82.50	Feasible
V-03	78		97.50	Very feasible
V-04	78		97.50	Very feasible
Average			**91.25**	Very feasible

The results of the assessment by material experts and media experts regarding digital teaching materials show that digital teaching materials are very suitable for use in the learning process with several suggestions for improvement. The results of the media suitability assessment by media experts are shown in Table 3.

The teaching materials produced in this research are in the form of a teaching materials website with a multi-representation approach which has several contents or sections aimed at making teaching materials materially complete and easy for users to use (user-friendly). This website-based physics teaching material

was created through the paid domain provider Niagahoster and the WordPress CMS application to create a website. The digital physics teaching materials developed can be accessed with the following link https://unnes.pusatbelajarskill.com/. The appearance of the digital teaching materials website section can be seen in Figure 1.

Table 3. Assessment of Media Feasibility of Teaching Materials by Media Experts

Validator Code	Total Score	Maximum Score	Percentage (%)	Criteria
V-01	98	108	90.74	Very feasible
V-02	94		87.04	Very feasible
V-03	105		97.22	Very feasible
V-04	104		96.30	Very feasible
Average			**92.82**	Very feasible

Figure 1. Website-Based Teaching Material Home Page Display

The home page displays a general overview of the menus on this website's teaching materials. The main menu of this teaching material includes concept maps, learning activities 1, learning activities 2, *Scratch* simulation, summary, evaluation, bibliography, my book, and profile.

The way to use digital teaching materials is to click on each menu to continue to the submenu or click home to return to the home page. This teaching material is equipped with a *Scratch* simulation used for digital practicum to make it easier for students to understand circular motion material. This website-based digital teaching material can be accessed online via the link https://unnes.pusatbelajarskill.com/ which is shared directly by researchers with validators and users. This website-based teaching material with a *Scratch*-assisted multi-representation approach can be accessed via smartphone and PC via the link that has been shared.

After being validated by a validator, digital teaching materials are tested for readability. The readability test was tested on class XII students with the consideration that the readability test respondents were students who had received circular motion material. The gap test results obtained were 81.94% in the easy-to-understand category, while the average readability questionnaire results were 87.59%. The results of readability questionnaire of website-based physics teaching material are in Table 4.

Table 4. Results of The Readability Questionnaire of Website-Based Physics Teaching Material

Aspects	Readability (%)
The writing in teaching materials is easy to read	89.58
The writing in the teaching materials uses clear sentences	88.19
The language in the teaching materials is easy to understand	85.07
Terms in teaching materials that are informative and easy to understand	87.85
Conformity with General Guidelines for Indonesian Spelling	89.24
Effective, efficient, and communicative language (clear and concise) does not give rise to double interpretations	87.15
The content of the teaching materials is beneficial in mastering the material	88.19
The images in the teaching materials are easy to understand and comprehend	85.42
Average	**87.59**

The teaching materials developed have a readability level in the easy-to-understand category because their preparation has been adjusted to the level of understanding of high school students.

Teacher responses and student responses to the teaching materials developed were obtained from response questionnaires to determine the effectiveness of the teaching materials and as a consideration for improving the teaching materials. The results of teacher responses and student responses in large-scale trials were 97.50% and 88.61% with very good criteria. The results of teacher responses and student responses in large-scale trials are in Table 5.

Table 5. Results of Teacher and Student Responses

Response	Percentage (%)	Criteria
Teacher	97.50	Very good
Student	88.61	Very good

Discussion

The development of digital teaching materials uses Research and Development (R&D) research with a 4-D development model. Teaching materials were developed containing circular motion material with the help of the *Scratch* simulation. This is based on a preliminary study that circular motion practicum using digital simulations is still rarely used by teachers and there is a lack of use of digital technology in physics learning.

The product developed is website-based digital teaching material with a *Scratch*-assisted multi-representation approach to circular motion material for class XI-F SMA. Teaching materials were developed based on guidelines for preparing teaching materials (Depdiknas, 2008; Kemdikbud, 2017; Kemendiknas, 2010) which have been adapted to the independent curriculum to support and assist teachers and students in the physics learning process.

The characteristics of website-based digital teaching materials with a multi-representation approach assisted by *Scratch* lie in the packaging of teaching materials in the form of websites and materials presented with multiple representations and equipped with *Scratch* simulations which can be used for digital practicum on circular motion material. This digital teaching material can be accessed online using a website link.

The characteristics of the digital teaching materials developed following research conducted by Awaly (2023), Permadi & Setyaningsih (2017), and Ramadayanty *et al*. (2021) that the characteristics of digital teaching materials with a multi-representation approach are supported by various representation formats, namely text formats in the form of material descriptions, image formats, mathematical formulations, graphics, and simulation videos.

The feasibility of website-based digital teaching materials using a *Scratch*-assisted multi-representation approach shows that the results are suitable for overall use based on the assessment of expert validators. Validation of digital teaching materials is assessed in terms of material, media, and content

base of students' conceptual understanding and critical thinking.

The material feasibility consists of the aspects of content, language, presentation, and characteristics. The material feasibility test percentage was 91.25% with very appropriate criteria. Meanwhile, the media feasibility consists of graphic aspects, software engineering, audiovisual communication, and other aspects. The media feasibility test percentage was 92.82% with very feasible criteria. This shows that the teaching materials that have been developed have been declared valid based on Aiken's validity and are suitable for use as supporting media for class XI-F physics learning regarding circular motion.

This is in line with research by Sunarti & Rusilowati (2021) that teaching materials can be used as learning resources, even though there are revisions from validators. Revisions to digital teaching materials have been carried out based on input from validators in several parts, namely improving the writing of terms and writing according to applicable guidelines, the composition of the material adjusted to the learning objectives of each meeting, and improving questions according to indicators.

The *Scratch* simulation displayed in this digital teaching material is adapted to the characteristics, conditions, and educational level of students, which are the main factors in making this digital teaching material so that it is suitable for use in the physics learning process of circular motion material in class XI-F.

The readability test of teaching materials was carried out on students who had received the circular motion material. This is based on the assumption that students have a perception of circular motion. The results of the readability test using the gap test obtained a score of 81.94%, while the results of the readability questionnaire were 87.59% in the easy-to-understand category, because when preparing teaching materials, it was adjusted to the conditions of ability and language mastery of high school students. Readability tests are carried out using text samples taken from teaching materials randomly by considering the same language structure and writing style between parts of the text from other parts. Good teaching materials must have good quality so that they can be easily understood (Zidatunnur *et al*., 2021).

The level of user response in using teaching materials is used to determine the level of effectiveness of the digital teaching materials being developed. Students' responses when they first opened the digital teaching materials showed curiosity about *Scratch* which had never been obtained before. Data on student responses to website-based teaching materials using a multi-representation approach assisted by *Scratch* shows a positive response with very good criteria. This is in line with research conducted by Setyandaru *et al.* (2017) that positive student responses are ≥ 50% of the total number of students, which can indicate that students agree with the teaching materials developed and implemented in the learning process.

Conclusion

Based on the development that has been carried out, it can be concluded that (1) based on validation from material experts and media experts, the teaching materials developed are in the very feasible category, so it can be concluded that website-based teaching materials with a multi-representation approach assisted by *Scratch* can improve students' understanding of concepts and critical thinking. (2) The characteristics of the teaching materials being developed in the packaging of the teaching materials in web form, and the material is presented with multiple representations and is equipped with a *Scratch* simulation which can be used for digital practicum on circular motion material. (3) The readability of website-based digital teaching materials using a multi-representation approach assisted by *Scratch* through cross-sectional tests and readability questionnaires given to students was 81.94% and 87.59% in the easy-to-understand category. (4) Teacher responses and student responses to the use and display of website-based digital teaching materials using a multi-representation approach assisted by *Scratch* show positive results.

References

Adegoke, A. B. (2011). Effect Of Multimedia Instruction on Senior Secondary School Students' Achievement in Physics. *European Journal of Educational Studies*, *3*(3), 537–541.

Ainsworth, S. (1999). The functions of multiple representations. *Computers and Education*, *33*(2–3), 131–152. https://doi.org/10.1016/s0360-1315(99)00029-9

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction*, *16*(3), 183–198. https://doi.org/10.1016/j.learninstruc.2006.03.001

Al Asy' Ari, H., Hardyanto, W., & Darsono, T. (2021). Development of Scratch Assisted E-Learning Teaching Materials on Wave Materials Physics Communication. *Phys. Comm*, *5*(2), 44–52. https://doi.org/10.15294/physcomm.v5i2.36478

Alighiri, D., Drastisianti, A., & Susilaningsih, E. (2018). Pemahaman Konsep Siswa Materi Larutan Penyangga dalam Pembelajaran Multiple Representasi. *Jurnal Inovasi Pendidikan Kimia*, *12*(2), 2192–2200. https://doi.org/10.15294/jipk.v12i2.15735

Awaly, M. A. (2023). *Pengembangan Bahan Ajar E-Book Multi Representasi untuk Meningkatkan Keterampilan Berpikir Kritis dan Keterampilan Berpikir Kreatif pada Materi Gelombang Mekanik SMA* [Universitas Pendidikan Indonesia]. https://repository.upi.edu/99456/

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads*, *2*(1), 48–54. https://doi.org/10.1145/1929887.1929905

Depdiknas. (2008). Panduan Pengembangan Bahan Ajar. In *Direktorat Pembinaan Sekolah Menengah Atas*. http://file.upi.edu/Direktori/FIP/Jur._Kurikulum_Dan_Tek._Pendidikan/194601291981012-Permasih/Pengembangan_Bahan_Ajar.Pdf

Gardner, P. (1992). The application of science to technology. *Research in Science Education*, *22*(1), 140–148. https://doi.org/10.1007/BF02356889

Habellia, R. C., & Suyanta, S. (2019). The Effectiveness of Inquiry-Based Science Web-Module on the Students' Thinking Skills and Positive Attitudes Towards Science. *Scientiae Educatia*, *8*(1), 23. https://doi.org/10.24235/sc.educatia.v8i1.4099

Häkkinen, P., Järvelä, S., Mäkitalo-Siegl, K., Ahonen, A., Näykki, P., & Valtonen, T. (2017). Preparing teacher-students for twenty-first-century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills. *Teachers and Teaching: Theory and Practice*, *23*(1). https://doi.org/https://doi.org/10.1080/13540602.2016.1203772

Intana, N. M., Hardyanto, W., & Akhlis, I. (2018). Pengembangan Multimedia Pembelajaran Fisika Berbasis Scratch pada Pokok Bahasan Hukum Oersted. *Unnes Physics Education Journal*, *7*(2). https://doi.org/10.15294/upej.v7i2.27461

Kapucu, M. S., Eren, E., & Avcı, Z. Y. (2014). Investigation of Pre-Service Science Teachers' Opinions about Using GoAnimate to Create Animated Videos Fen Bilgisi Öğretmen Adaylarının Animasyon Oluşturmada GoAnimate Kullanımına İlişkin Görüşlerinin İncelenmesi. *Turkish Online Journal of Qualitative Inquiry*, *5*(4), 23–40. https://doi.org/10.17569/tojqi.45542

Kemdikbud. (2017). *BUKU TEKS DAN PENGAYAAN: Kelengkapan dan Kelayakan Buku Teks Kurikulum 2013 Serta Kebijakan Penumbuhan Minat Baca Siswa* (V). Pusat Penelitian Kebijakan Pendidikan dan Kebudayaan, Balitbang.

Kemendiknas. (2010). Panduan Pengembangan Bahan Ajar Berbasis Web. In *Kemendiknas*. http://file.upi.Edu/Direktori/Fip/Jur._Kurikulum_Dan_Tek._Pendidikan/194601291981012-Permasih/Pengembangan_Bahan_Ajar.Pdf

Kohl, P. B., D., R., & N.D., F. (2008). Patterns of multipe representation use by experts and novices during physics problem solving. *Physical Review Special Topics - Physics Education Research*, *4*(1), 1–13. https://doi.org/10.1103/PhysRevSTPER.4.010111

Kohl, P. B., Rosengrant, D., & Finkelstein, N. D. (2007). Strongly and weakly directed approaches to teaching multiple representation use in physics. *Physical Review Special Topics - Physics Education Research*, *3*(1), 1–10. https://doi.org/10.1103/PhysRevSTPER.3.010108

Mulhayatiah, D., Sinaga, P., & Hidayatulloh, R. (2022). Analisis Kebutuhan Pengembangan Bahan Ajar Berbasis Multi Representasi Untuk Meningkatkan Kompetensi Guru Fisika. *SPEKTRA: Jurnal Kajian Pendidikan Sains*, *8*(1), 64. https://doi.org/10.32699/spektra.v8i1.229

Opra A., N., Asrizal, & Kamus, Z. (2013). Pembuatan Bahan Ajar Fisika Berbasis Web Pada Konsep Termodinamika Untuk Pembelajaran Menurut Standar Proses Siswa Kelas Xi Sma. *Pillar of Physics Education*, *2*, 9–16. https://api.semanticscholar.org/CorpusID:58384951

Permadi, D., & Setyaningsih, K. (2017). Pengembangan Modul Multi Representasi Berbasis Kontekstual pada Materi Fluida Statis untuk Meningkatkan Kemampuan Berpikir Kritis. *Jurnal Ilmu Fisika Dan Pembelajarannya (JIFP)*, *1*(1), 5–10. https://doi.org/10.19109/jifp.v1i2.1629

Ramadayanty, M., Sutarno, S., & Risdianto, E. (2021). Pengembangan E-Modul Fisika Berbasis Multiple

Representation untuk Melatihkan Keterampilan Pemecahan Masalah Siswa. *Jurnal Kumparan Fisika*, 4(1), 17–24. https://doi.org/10.33369/jkf.4.1.17-24

Saputra, B. E., Pathoni, H., & Kurniawan, D. A. (2020). Pengambangan E-Modul Fisika Berbasis Multirepresentasi pada Materi Gerak Lurus. *Jurnal Pendidikan Fisika*, 5(1), 39–44. https://online-journal.unja.ac.id/EDP/article/view/8843

Setyandaru, T. A., Wahyuni, S., & Putra, P. D. A. (2017). Pengembangan Modul Pembelajaran Berbasis Multirepresentasi pada Pembelajaran Fisika di SMA/MA. *Jurnal Pembelajaran Fisika*, 6(3), 218–224.

Shavira, T., Ertikanto, C., & Suyatna, A. (2019). Pengaruh Penggunaan Modul Kontekstual Berbasis Multirepresentasi pada Materi Gravitasi Newton Terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan Fisika*, *VII*(2), 143–155. https://doi.org/http://dx.doi.org/10.24127/jpf.v7i2.1429

Sudijono Anas. (2014). *Pengantar Statistik Pendidikan*. PT. Raja Grafindo Persada.

Sugiyono. (2015). *Statistika Untuk Penelitian* (26th ed.). Alfabeta.

Sunarti, S., & Rusilowati, A. (2021). Pengembangan Bahan Ajar Digital Gerak Melingkar Berbantuan Scratch Berbasis Science, Technology, Engineering, and Mathematics. *Unnes Physics Education Journal*, 9(3), 283–290. https://doi.org/10.15294/upej.v9i3.45869

Sunyono. (2015). *Model Pembelajaran Multipel Representasi; Pembelajaran Empat Fase dengan Lima Kegiatan: Orientasi, Eksplorasi Imajinatif, Internalisasi, dan Evaluasi* (1st ed.). Media Akademi.

Tambade, P. S., & Wagh, B. G. (2011). Assessing the Effectiveness of Computer Assisted Instructions in Physics at Undergraduate Level. *International Journal of Physics & Chemistry Education*, *3*(2), 127–136. https://doi.org/10.51724/ijpce.v3i2.197

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. https://doi.org/10.1016/0022-4405(76)90066-2

Zidatunnur, S. F., Rusilowati, A., & Artikel, I. (2021). Keterbacaan dan Kepraktisan Bahan Ajar Digital Gerak Melingkar Berbantuan Scratch Berbasis STEM untuk Mahasiswa. *Unnes Physics Education Journal*, *10*(2). https://doi.org/10.15294/upej.v10i2.54187