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Development of Scratch-Based Interactive Animation Media on Uniformly Accelerated Rectilinear Motion to Improve Students' Understanding of Concepts

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Abstract

Technological developments impact the learning process as well as the utilization of increasingly creative and innovative learning media. The learning medium becomes essential to the achievement of learning objectives. This study aims to develop scratch-based learning media on uniformly accelerated rectilinear motion material to enhance high school students' concept understanding. The research method used is R&D (Research and Development) with the 4D model (Define, Design, Develop, and Disseminate). Data collection in this study was done by distributing feasibility test questionnaires consisting of three aspects, namely presentation, material, and language, to one expert lecturer in physics education and 13 prospective physics teacher students. Based on the feasibility test results by the validator on the learning medium, the score of each aspect is 3.1, 3.1, and 2.9, with an average score of 3.1 in the feasible category. Therefore, the learning medium that has been developed is feasible to use to increase students' conceptual understanding of uniformly accelerated rectilinear motion material. This study suggests that incorporating scratch-based learning media into other materials can enhance students' comprehension of the subject matter. The recommendations for further research are to test learning media on a large scale at school.

Keywords: concept understanding; interactive media; perpendicular motion; scratch

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INTRODUCTION

The phenomenon of the Industrial Revolution 4.0 is currently bringing enormous changes to the human life sector. This can be seen from the increasingly sophisticated digital technology that is always developing in Indonesia (Martoredjo, 2023; Aspi & Syahrani, 2022; Reflianto & Syamsuar, 2018). The era of the Industrial Revolution 4.0 can also be seen in increased connectivity, artificial intelligence, interaction, and digital system development (Lase, 2019). Along with the development of technology, of course, it will impact changes in other fields, including the field of education in Indonesia.

The education system in Indonesia in the era of the Industrial Revolution 4.0 provides changes to the learning process in schools. This can be seen from

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educators who are required to develop various creative and innovative learning media, including utilizing computer technology and gadgets in the learning process (Agustini et al., 2021; Firmadani, 2020). Appropriate learning media will support learning to be more effective and efficient in achieving learning objectives (Puspitarini & Hanif, 2019). The utilization of computer technology and gadgets creates new opportunities with the presentation of more creative and innovative learning media (Bali et al., 2021; Dewi & Firman, 2019). Multimedia can present more informative material to students to make the information received more diverse (Pratidhina et al., 2020). Therefore, developing increasingly sophisticated technology can encourage educators to create technological updates in the learning process.

Nowadays, the use of technology in learning is very necessary to support the achievement of students' learning goals. Creative and innovative presentation of material using technology-based learning media can excite students about learning (Qodariah & Rabbani, 2022; Umamah & Mahmudi, 2020). Technology-based learning media can combine text, art, sound, images, animations, and videos to be delivered interactively (Kurniawati & Nita, 2018; Dalacosta, 2009). This medium makes it easier for students to understand the material because they can listen to the explanation while seeing animations and images and reading explanations in a text (Sutopo, 2008). In addition, technology-based learning media also provides benefits to students, enabling students to adjust their learning speed, time, and place of learning and can encourage students to learn independently (Mou, 2023). Students must learn media like this when learning abstract material concepts such as physics.

Most students have an unfavourable perception of physics subjects. Learners think physics subjects are difficult and scary (Sastradika et al., 2020; Kurniawati & Nita, 2018; Cetin, 2016). This is because many diverse formulas and abstract physics concepts require students to understand them deeply (Karnando et al., 2023; Bekti et al., 2021; Jufrida et al., 2019). In addition, physics is considered difficult because, at the same time, students must perform multiple representations, apply formulas in calculations, conduct experiments, provide conceptual explanations, and make graphs (Kereh et al., 2020; Planinic et al., 2013). Therefore, not many students like physics lessons because of their abstract concepts, so they experience misconceptions in learning physics.

The problem of misconceptions that occur to students during the learning activity process is related to the material of uniformly accelerated rectilinear motion. Yolanda (2017) states that students cannot distinguish between displacement and distance in an event, so they assume that uniformly accelerated rectilinear motion only has acceleration and do not know the existence of negative acceleration or deceleration. In addition, in the learning process, uniformly accelerated rectilinear motion material tends to take place in one direction only, namely, the teacher provides material while students listen and record the material delivered by the teacher (Kereh et al., 2020). Novitasari (2016) stated that the average recapitulation of the percentage of students who experienced misconceptions in straight-motion kinematics material was 80.11%, while the average percentage of students who knew the concept was 19.89%. The average recapitulation results show that the average percentage of students who experience misconceptions is greater than that of students who know the concept. This will certainly impact student learning outcomes, which can be

seen in students' understanding of concepts in material that is still lacking (Sukadi & Khaerul, 2020). Previous researchers tried to develop POE-based the student worksheets to overcome this, but the efforts made still had shortcomings. POE is a learning model that aims to identify students' prediction skills and the reasons behind their predictions related to a phenomenon (Muna, 2017). The shortcomings of learning media are that it is still conventional, so it is still limited in terms of interactivity and the ability to provide direct feedback. Based on this fact, it is necessary to develop new interactive learning media to help students improve their concept understanding.

New interactive learning media have been developed, including the Scratch application. Scratch is an application used in making games, interactive stories, music, artwork, and animation (Laily & Mulyani, 2022; Martanti et al., 2013). Learning media using Scratch can show animations that demonstrate a lesson's basic principles or functions (Sutikno, Susilo, & Hardiyanto, 2018). Scratch can also be used to simulate abstract physics learning so that the learning process can effectively improve students' conceptual understanding of physics material (Martanti et al., 2013). The advantage of learning media using scratch compared to other applications is that learning media is relatively easier and simpler than other applications such as Adobe Flash and similar applications (Arfiansya et al., 2019). In addition, Scratch is an easy-to-use programming language that allows for a meaningful learning process (Broza et al., 2023). Therefore, learning media using scratch is expected to help students improve their understanding of physics concepts, especially in uniformly accelerated rectilinear motion material.

Based on this explanation, this study aims to create scratch-based learning resources based on uniformly accelerated rectilinear motion material that will enhance students' comprehension of concepts. The difference between this researcher and the previous researcher is that it focuses more on the material of regular straight-line motion to help students improve their understanding of concepts by collaborating with the material, quizzes, and simulation menus. The research and development method is applied in developing this product to obtain a feasible product to implement in the learning process. Therefore, this research is entitled "Development of scratch-based interactive animation media on uniformly accelerated rectilinear motion to improve students' concept understanding."

METHOD

This type of research is development research (research and development) using the 4D approach model (Define, Design, Develop, and Disseminate). (Marpaung, Supriadi, & Nugraha, 2019). The research aims to develop scratch-based physics learning media on the subject of regular straight-line motion and test its feasibility. The following are the stages of research using the 4D approach model presented in Figure 1.

The define step was conducted by identifying the issues that students experienced during the uniformly accelerated rectilinear motion learning process. To find out these problems, researchers conducted a literature review of several articles. After conducting a literature study, researchers found that students need a learning medium to facilitate their comprehension of learning materials, especially the material of regular straight motion. The currently popular learning medium is scratch-based. This medium can facilitate students understanding of learning materials so that their' concept mastery of certain materials can increase (Martanti et al., 2013). Therefore, researchers use scratch-based learning media to try to

overcome students' problems with the material of regular straight-line motion with the sub-materials discussed regarding acceleration, uniformly accelerated rectilinear motion accelerated and slowed down uniformly accelerated rectilinear motion graphs, and uniformly accelerated rectilinear motion mathematical equations.

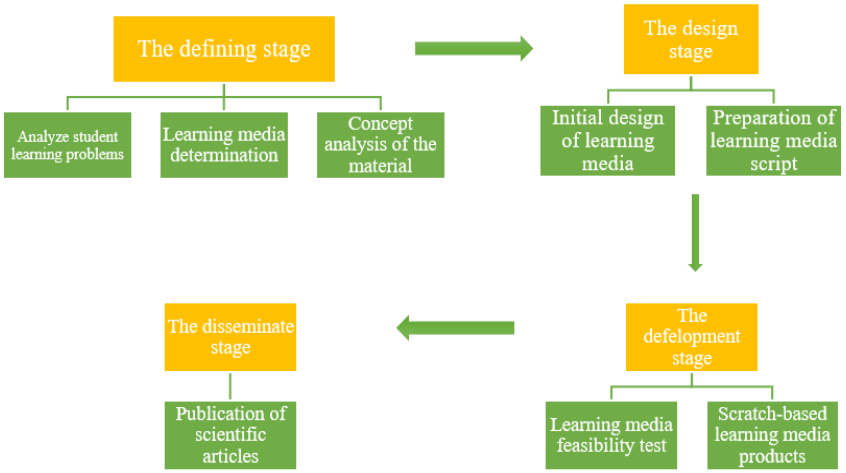

Figure 1 Flowchart of the 4D model development procedure

The design step is carried out by designing the learning medium according to the sketches that have been planned. The initial appearance of the learning medium is presented with a cover accompanied by the title of the material raised, the opening sound background "welcome to the material of straight motion changes regularly," and there is a start button. This start button, when pressed, will change the menu display. When in the menu view, there will be a background song that accompanies it. Besides that, there is a developer identity button and 3 menus, namely material, simulation, and quiz. This material menu contains core competencies, basic competencies, achievement indicators, learning objectives, and five uniformly accelerated rectilinear motion sub-materials, such as the definition of acceleration, uniformly accelerated rectilinear motion, uniformly accelerated rectilinear motion graphs, examples of uniformly accelerated rectilinear motion problems, and types of uniformly accelerated rectilinear motion. While in the material menu, there will be a back sound that accompanies.

The initial display of this simulation will have several features, such as practicum instructions, home, and start buttons. If the start button is pressed, it will go to the simulation display. The simulation display is designed to determine the distance of an object at a certain time (x_t), with variables that can be changed being initial speed (v_0), time (t), initial distance (x_0), and acceleration (a). Furthermore, the initial display of the quiz contains quiz instructions and a start button; when the start button is pressed, the quiz will begin. If the student has answered during the quiz, the question will move on to the next question. However, if the student gives the correct answer, the score will increase; if the answer is wrong, the score will not increase. After completing all the quiz questions, there will be a discussion of the quiz questions.

The development stage is carried out by conducting a feasibility test of the learning media to determine the

feasibility level of the learning media developed. The feasibility test determines whether the developed media can be applied in the classroom to improve the measured variables. The feasibility test was carried out by distributing questionnaires on the feasibility of learning media to validators, consisting of 13 prospective physics teachers and one expert lecturer in physics education. The 13 prospective physics teachers were chosen because they have practical experience developing learning media and understand the challenges students face in learning physics. Meanwhile, one physics education lecturer was selected because one of the lecturers has expertise in physics learning media, which can provide an in-depth academic perspective and ensure that this research meets high academic standards. The results of this feasibility test are used as revision material so that the learning medium is feasible for students. The distributed feasibility test questionnaire consists of 20 statements. The following 20 statements in the learning media feasibility test questionnaire are presented in Table 1.

Table 1 Learning media feasibility test statement.

Aspects		Statement
Presentation	1.	Completeness of identity
	2.	Appropriateness of layout proportions
	3.	Appropriateness of color proportion
	4.	Appropriateness of background selection
	5.	Appropriateness of font selection
	6.	Consistency of button display
	7.	Ease of access
	8.	Creativity and innovation
	9.	Media development opportunities against the development of science and technology
Material	10.	Conformity with physics concepts
	11.	Use, utilize, and select specific procedures or operations
	12.	Presenting the concept of perpendicular motion in various forms of mathematical representations
	13.	Provide examples and non-examples of the concept of perpendicular motion.
	14.	Apply concepts or algorithms for problem-solving.
	15.	Classify objects according to their properties
Language	16.	Language structure is easy to understand
	17.	Effective sentences, no ambiguity
	18.	The language used is communicative
	19.	Spelling used by EYD
	20.	The terms used have appropriate meanings

The feasibility test analysis of learning media is carried out by grouping data in the form of scores or values obtained from the feasibility test questionnaire results. The feasibility test results used in this study were measured using a Likert scale. After obtaining interval data, an analysis was carried out to determine the feasibility of learning media using ideal evaluation criteria on a scale of 4 (Juniantari, 2017). The following are the ideal assessment criteria on a scale of 4, which can be seen in Table 2.

Table 2 Ideal assessment criteria on a scale of 4

Renting Score	Category
X > 3.25	Very feasible
3.25 ≥ X ≥ 2.5	Worth
2.5 ≥ X ≥ 1.75	Less Feasible
1.75 > X	Not Feasible

The dissemination stage is the final stage of product development. This stage is carried out by disseminating scientific articles that will be published in sinta-indexed national journals to the community to provide learning tools for regular straight-line motion through comments and input from validators.

RESULT AND DISCUSSION

This research is into developing scratch-based learning media on material that changes straight and uniform movements to improve understanding of concepts for class X SMA/MA students. Research and development of learning media are carried out by the stages of the 4D model.

The define stage is the initial stage to establish the basis for research and development based on the results of the analysis carried out by the researcher. At the defined stage, the researcher carried out two steps, namely, initial analysis and student analysis. The results of the definition stage in the initial analysis were that students found problems where they could not differentiate between displacement and distance in an event, so they assumed that uniformly accelerated rectilinear motion only had acceleration and did not know that there was negative acceleration or deceleration. Apart from that, in the uniformly accelerated rectilinear motion material learning process, they use the lecture method, where the teacher only provides the material while the students listen and take notes on the material presented by the teacher.

Apart from that, at the initial analysis stage, researchers obtained learning media that could help students understand the material on straight and uniform movements. The literature review (literature study) results show that interactive multimedia learning media can help improve students' understanding of concepts (Gunawan et al., 2014). One of the interactive multimedia learning media chosen is scratch. Scratch was chosen because the application used can create games, interactive stories, music, works of art, simulations, and animation. The second step is student analysis, carried out through a literature review. Based on the results of the literature review, it was found that students' level of conceptual understanding was still low. This was shown by previous researcher Novitasari (2016), who stated that in the recapitulation results, the average percentage of students who experienced misconceptions about the kinematics of rectilinear motion was 80.11%, while the average percentage of students who knew the concept was 19.89%.

The design phase involves designing learning media using the Scratch application. Scratch-based learning media combines several multimedia elements, such as images, text, audio, and animation. This learning medium does not only present writing; students can also listen to and see illustrations and images related to the material. This learning media development design consists of three main menus, including material, quizzes, and simulations. The initial appearance and main menu of this scratch-based learning medium are presented in Figure 2.

(a)

(b)

Figure 2 a) Scratch-based learning media initial display, b) Scratch-based learning media menu display

The material page display contains basic competencies, indicators, learning objectives, and a discussion of uniformly accelerated rectilinear motion material, which consists of 5 sub-chapters including 1) understanding acceleration, 2) understanding uniformly accelerated rectilinear motion, 3) types of uniformly accelerated rectilinear motion, 4) uniformly accelerated rectilinear motion graph and 5) examples of uniformly accelerated rectilinear motion problems and their discussions. Each sub-chapter is discussed in depth to help students understand the concept of regular straight motion. In addition, in the discussion of uniformly accelerated rectilinear motion material, a conversation between two people discussing uniformly accelerated rectilinear motion is presented to ensure that students are not bored. Furthermore, it also presents a problem that must be solved, and practice problems must be used to distinguish examples of uniformly accelerated rectilinear motion and non-examples of uniformly accelerated rectilinear motion, which are presented in the form of drag and drop. In this drag-and-drop presentation, when students drag each answer choice to the correct or incorrect answer box, feedback will appear. When students drag an option to the correct answer box, the box will turn green. If the answer is wrong, the box will turn red. The following is the content displayed on the material menu presented in Figure 3.

(a)

(b)

(c)

(d)

Figure 3 a) Display of material explanation using human characters in the content of the material; b) Display of exercise questions on the contents of the material menu c) Display of problem-solving exercises on the contents of the material menu; d) Display of exercise questions using drag and drop on the contents of the material menu

The quiz content page contains four multiple-choice questions based on the learning objectives. This quiz aims to test students' understanding after learning uniformly accelerated rectilinear motion material. The initial display of the quiz presents quiz instructions and a start button. This quiz is designed so that if the student answers correctly, the score will increase by 25 points, but if the student answers incorrectly, the score will not increase. After doing all the quizzes, students will know the number of scores they get. This quiz is set; if the student scores less than 51, they will get a notification: "Cheer up, don't despair," but when the student scores more than 51, they will get a notification: "Congratulations, you did well on the quiz." After students have done all the quizzes, they can see the quiz discussion that has been presented.

The simulation page contains a simulation of uniformly accelerated rectilinear motion material by determining the distance of objects at a certain time. The uniformly accelerated rectilinear motion simulation display has three buttons, namely home, play, and restart, and then uniformly accelerated rectilinear motion variables that can be varied in value along with their bound variables. The home button serves to return to the menu display. The play button starts the experiment after setting the variable's value. The restart button returns the bicycle object to its initial position when you want to re-vary the value of the uniformly accelerated rectilinear motion variable. This simulation helps students practice the knowledge they have learned. The following is the uniformly accelerated rectilinear motion simulation display presented in Figure 4.

The learning medium that has been developed is tested by a team of validators to determine its feasibility level. The learning media that has been assessed has several shortcomings, so revisions need to be made according to criticism and suggestions from the validators. The suggestions from the validators on scratch-based learning media are as follows: In the explanation of the acceleration illustration using three objects, the acceleration value of each object should be included; the appearance of the cover colour with the font colour is still not appropriate; in the simulation section, a variable setting whose value can be varied; in the quiz work section, the assessment score should be hidden; and in the simulation section, student activity activities should be added.

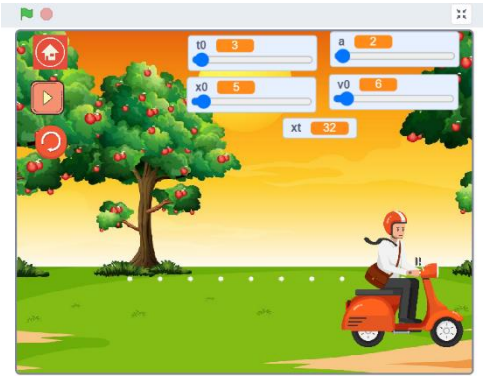

Figure 4 Simulation view of straight-line motion

In the development stage, the learning medium developed is subjected to feasibility testing to determine its level of feasibility. The feasibility test results for scratch-based learning media analyzed by validators are shown in Figures 5, 6, and 7.

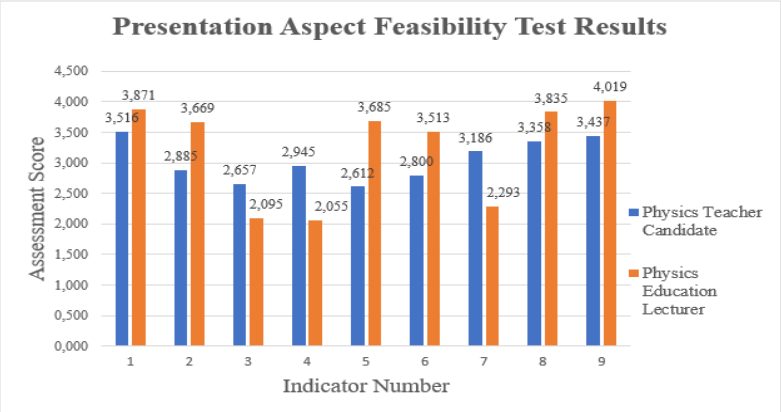

Figure 5 Presentation aspect feasibility test results

Figure 5 is the result of two validators' feasibility test of the presentation aspect. The presentation aspect feasibility test results graph shows that almost all assessments are above 2.5 except for indicators 3, 4, and 7 from Physics Education lecturers. Indicator number 3 is "appropriateness of colour proportion," and indicator number 4 is "appropriateness of background selection." These two indicators are related to each other. The reason for the low indicator is found in the validator's comments, namely that the selection of background colour with the colour of the writing is not appropriate on the cover display. Indicator number 7 is "Ease of access." Indicator number 7 received a low score because this learning medium has no instruction. Although the three indicators received low scores, they can still be considered feasible variables. It can be observed from the mean score on indicator 3 of 2.617, indicator 4 of 2.881, and indicator 7 of 3.122. Referring to Table 2, the assessment score between 3.25 and 2.5 is in the feasible category.

The Figure 5 graph of the feasibility test results for the presentation aspect also shows a high assessment with a score of almost 4.00. This highest assessment score is found in indicators 1, 8, and 9 from Physics Education lecturers and prospective physics teachers. Indicator number 1 is "completeness of identity," indicator number 8 is "creativity and innovation," and indicator number 9 is "opportunities for media development towards the development of science and technology." The three indicators are related to each other. Indicators numbers 1, 8, and 9 get high scores because the scratch-based learning media that has been developed presents illustrations, animations, audio, interesting human characters in conveying material, and features to go to the desired menu page. Presentation of material using learning media equipped with animation, text, and images can stimulate students for the material they learn (Lee et al., 2014; Yuliyanti & Mintohari, 2021). In addition, the media that has been developed contains interactive stories, simulations, and quizzes that can involve students interacting with the media.

All validators' average result of the feasibility test of the learning media presentation aspect obtained a value of 3.057. Referring to Table 2, the assessment score between $3.25 \geq X \geq 2.5$ is categorized as feasible. These results show that the scratch-based learning medium that has been developed has an attractive appearance. This attractiveness can be caused by scratch applications that are interactive and media-rich because they can combine audio, animation, interactive stories, simulations, quizzes, and games (Martanti et al., 2013; Qodariah & Rabbani, 2022). Learning

media presented in an attractive manner can foster student motivation for learning (Widiyasanti & Ayriza, 2018). In addition, learning media with an attractive and creative appearance can help students understand the material well (Maulina & Pahamzah, 2019; Sutarno & Mukhidin, 2013). Therefore, scratch-based learning media can help students improve their understanding of regular straight-line motion.

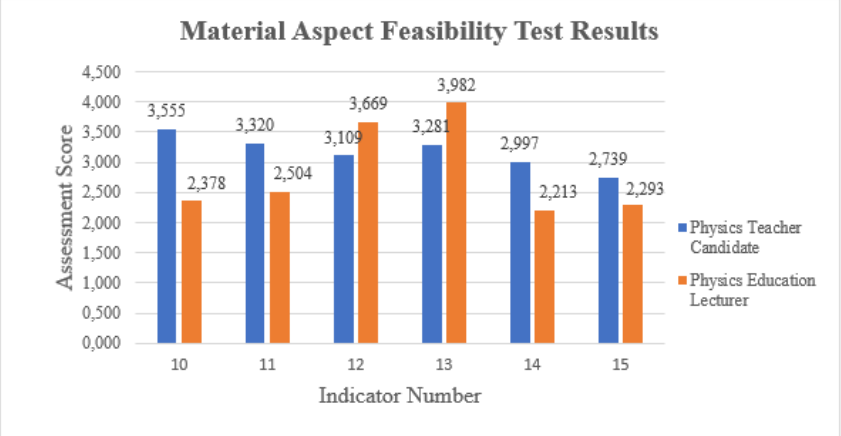

Figure 6 Graph of material aspect feasibility test results

Figure 6 is a graph of the results of the material aspect feasibility test by two validators. The material aspect feasibility test results graph shows that the highest assessment scores are on indicators 12 and 13 from physics education lecturers. Indicator number 12 is "Presenting the concept of regular straight motion in various forms of mathematical representation." The validator gave a high score on the indicator because the material presented described the GLBB mathematical equation and was accompanied by example and practice problems. Indicator 13 is "Provide examples and non-examples of the learned concept of perpendicular motion." The validator gave a high score on this indicator because examples and non-examples in uniformly accelerated rectilinear motion material were presented as drag-and-drop interactive exercises. Mardiana et al. (2023) stated that the presentation of drag-and-drop exercises can help students understand the material easily. Therefore, the delivery of material by providing examples and non-examples in the form of interactive exercises can help students understand concepts well.

The average result of the material aspect feasibility test by two validators is 3.144, with a decent category. These results indicate that the material presented with the help of the initial application can help increase student concept understanding. Examples of problems, practice problems, illustrations, animations, and interactive stories accompany explaining the material in this scratch-based learning medium. The presentation of visual illustrations in learning has a strategic role because it can help students concretize something abstract (Azizah & Budijastuti, 2021). In addition, the explanation of the material is not only in the form of text but also accompanied by human voices and audio effects. Sudarma et al. (2015) stated that learning media equipped with human voices and audio effects can easily attract emotions, make the tone more entertaining, and focus more on learning. The existence of audio

and illustrations that support the explanation of the material will enable students to comprehend the lesson well, especially the physics lesson.

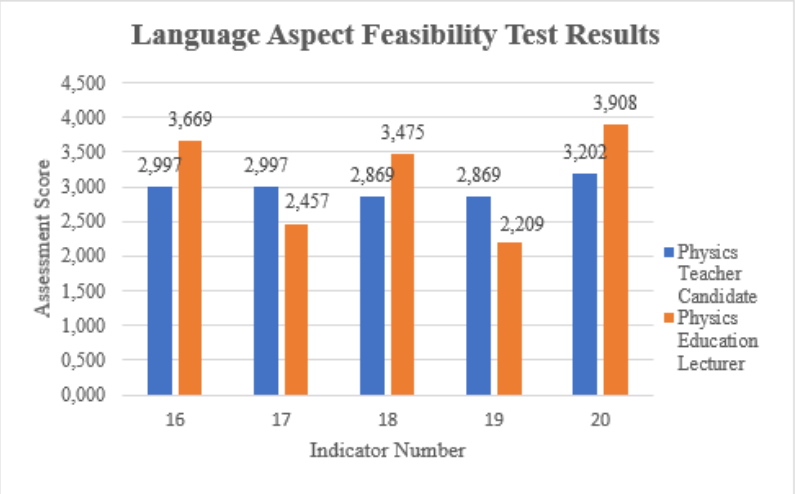

Figure 7 Graph of language aspect feasibility test results

Figure 7 is a graph of the results of the language aspect feasibility test by two validators. The language aspect feasibility test results graph shows that almost all indicators obtained an assessment score of 2.50 except indicators 17 and 19 from the Physics Education lecturer. Indicator number 17 is "Effective sentences, not ambiguous," and indicator number 19 is "Spelling used in accordance with EYD." The validator commented that there were ambiguous sentences in the learning objectives section, and the language explanation was communicative and structured. In addition, indicators 16 and 20 showed high assessment scores by physics education lecturers and prospective physics teachers. Indicator 16 is the language structure that is easy to understand, and indicator 20 is that the terms used have appropriate meanings. Both indicators are related to each other. The validator gave a high score on the indicator because the language used in explaining the material uses common language. This is aimed at helping students understand the uniformly accelerated rectilinear motion subject well.

The average result of the two validators' feasibility test of language aspects is 2.998, with a decent category. These results indicate that the developed learning media use language that is appropriate for SMA/MA students. Language is the most important part of learning media development. This is because language using everyday vocabulary can help students better understand their learning material (Fridayanti et al., 2022). Hasanah et al. (2019) stated that using simple language to explain material can improve students' concept understanding. Therefore, delivering material using simple language is an important factor in students' success in understanding the material.

The feasibility test results from these three aspects earned a mean score of 3.068. These results indicate that the scratch-based learning medium that has been developed is categorized as feasible. The research results align with those of Martanti et al. (2013) and Qodariah & Rabbani (2022), who stated that scratch-based learning media is feasible for improving students' concept understanding. Therefore, scratch-based

learning media can enhance students' concept comprehension while learning regular straight-motion material.

At the dissemination stage, researchers carry out activities to compile articles as an output of the developed learning media. The articles that have been compiled will then be disseminated through a national journal with a sinta index.

Scratch-based learning media has advantages over other learning media. The advantages of scratch-based learning media are that they can present interactive stories, games, animations, and abstract physics learning quizzes (Laily & Mulyani, 2022; Martanti et al., 2013). Scratch can also be used to simulate abstract physics learning so that the learning process can effectively improve students' conceptual understanding of physics material (Martanti et al., 2013). The use of scratch can be accessed online and offline from the scratch application on a PC, laptop, or Android so that it is more flexible (Nisa et al., 2022). The use of scratch-based learning media is more practicable in learning processes as it can provide a pleasant learning environment and arouse students' enthusiasm for learning (Ningrum et al., 2023). In addition, scratch application-based learning media can create student interaction in the learning process as they are complemented by concrete examples and videos that support the explanation of the material (Islami & Setiawan, 2023). Using scratch application-assisted learning media can help educators create more innovative and creative learning media to enhance student understanding.

CONCLUSION

The results showed that scratch-based learning media on uniformly accelerated rectilinear motion enhanced concept understanding and obtained an assessment score 3.068. Based on the score obtained, the learning media that have been developed are categorized as feasible. This means that scratch-based learning media is feasible to use to enhance students' concept comprehension of the material of regular straight motion. The implied conclusion from this research is that scratch-based learning media can be implemented in other subjects to help students better comprehend the subject matter. The recommendation for further research is to test learning media on a large scale at school.

REFERENCES

Agustini, K., Wahyuni, D. S., Mertayasa, I. N. E., Sugihartini, N., & Subawa, I. G. B. (2022). Digital learning media innovation and learning experience: Creating interactive flipbook for vocational student. In *IConVET 2021: Proceedings of the 4th International Conference on Vocational Education and Technology, IConVET 2021, 27 November 2021, Singaraja, Bali, Indonesia* (p. 133).

Arfiansyah, L. P., Akhlis, I., & Susilo. (2019). Pengembangan media pembelajaran berbasis *scratch* pada pokok bahasan alat optik. *Unnes Physics Education Journal, 8* (1), 67-74.

Aspi, M. & Syahrani, S. (2022). Profesional guru dalam menghadapi tantangan perkembangan teknologi Pendidikan. *ADIBA: Journal education, 2*(1), 64-73.

Azizah, V. N., & Budijastuti, W. (2021). Media pembelajaran ilustratif e-book tipe flipbook pada materi sistem imun untuk melatihkan kemampuan membuat poster. *Jurnal Inovasi Pembelajaran Biologi, 2*(2), 40-51.

Bali, M. M. E. I., Baharun, H., Madanibillah, A., Muali, C., Lukman, N. K. A., & Bon, A. T. (2021). Innovative learning media based on e-learning in the new normal era. In *Proceedings of the 11th Annual International Conference on*

Industrial Engineering and Operations Management.

Bekti, N., Dwi, W., Gola, N., Raudhotus, R., Nuraini, L., & Anggraeni, F. K. A. (2021). Pengembangan modul interaktif berbasis macromedia flash 8 pada materi optik geometri. *ORBITA: Jurnal Kajian, Inovasi dan Aplikasi Pendidikan Fisika, 7*(1), 123-135.

Broza, O., Biberman-Shalev, L., & Chamo, N. (2023). "Start from scratch": Integrating computational thinking skills in teacher education program. *Thinking Skills and Creativity*, *48*, 101285.

Cetin, A. (2016). An analysis of metaphors used by high school students to describe physics, physics lesson and physics teacher. *European Journal of Physics Education*, *7*(2), 1-20.

Dalacosta, K., Kamariotaki-Paparrigopoulou, M., Palyvos, J., & Spyrellis, N. (2009). Multimedia application with animated cartoons for teaching science in elementary education. *Computers & Education, 52*(4), 741–748.

Dewi, M. P. & Firman, F. (2019). Pengaruh lembar kerja praktikum terhadap keterampilan proses sains siswa kelas IV SD. *Edukatif: Jurnal Ilmu Pendidikan, 1* (3), (170-176).

Firmadani, F. (2020). Media pembelajaran berbasis teknologi sebagai inovasi pembelajaran era revolusi industry 4.0. *Prosiding Konferensi Pendidikan Nasional.*

Fridayanti, Y., Irhasyuarna, Y., Putri, R. F. (2022). Pengembangan media pembelajaran audio-visual pada materi hidrosfer untuk mengukur hasil belajar peserta didik SMP/MTS. *Jurnal Pendidikan dan Ilmu Sosial, 1* (3).

Gunawan, G., Harjono A., Sahidu, H., & Sutrio, S. (2014). Penggunaan multimedia interaktif dalam pembelajaran fisika dan implikasinya pada penguasaan konsep mahasiswa. *Jurnal Pijar MIPA, 9* (1), 15 - 19.

Islami, N. P. & Setiawan, A. M. (2023). Urgensi pengembangan media pembelajaran berbasis multimedia interaktif scratch sebagai upaya meningkatkan minat belajar siswa kelas VII pada materi pesawat sederhana. *Seminar Nasional Pendidikan IPA dan Matematika ke-1*, 731-738. Malang: Pendidikan IPA dan Matematika.

Jufrida, J., Kurniawan, W., Astalini, A., Darmaji, D., Kurniawan, D. A., & Maya, W. A. (2019). Students' attitude and motivation in mathematical physics. *International Journal of Evaluation and Research in Education, 8*(3), 401-408.

Juniantari, M. (2017). Pengembangan perangkat pembelajaran matematika berorientasi pendidikan karakter dengan model treffinger bagi siswa SMA. *Journal of Education Technology, 1* (2),71-76.

Karnanningdo, R. R., Sugiarti, S., & Lefudin, L. (2023). Pengembangan e-modul pembelajaran fisika berbasis web untuk meningkatkan literasi sains. *Berkala Ilmiah Pendidikan Fisika, 11*(1), 104.

Kereh, C. T., Asryanty, W. O., & Sapulette, H. (2020). Penggunaan software crocodile physics 6.0.5 dalam pembelajaran fisika materi gerak lurus berubah beraturan (GLBB). *Jurnal Inovasi dan Pembelajaran Fisika, 7* (1), 64-80.

Kurniawati, I. D. & Nita, S. (2018). Media pembelajaran berbasis multimedia interaktif untuk meningkatkan pemahaman konsep mahasiswa. *Journal of Computer and Information Technology, 1* (2), 68-75.

Laily, S. J. & Mulyani. (2022). Pengembangan media quizland berbasis scratch games pada pembelajaran tematik sub tema aku dan cita-citaku kelas IV sekolah dasar. *JPGSD, 10* (6), 1271-1280.

Lase, D. (2019). Pendidikan di era revolusi industri 4.0. *SUNDERMANN: Jurnal Ilmiah Teologi, Pendidikan, Sains, Humaniora dan Kebudayaan, 12*(2), 28-43.

Lee, Y. H., Hsiao, C., & Ho, C. H. (2014). The effects of various multimedia instructional materials on students' learning responses and outcomes: A comparative experimental study. *Computers in Human Behavior*, *40*, 119-132.

Mardiana, Sukmawati, R. A., Kapsul., Purba, H. S., & Pamuji, R. (2023). Pengembangan media pembelajaran interaktif berbasis web pada materi sistem ekskresi manusia menggunakan metode demonstrasi. *Computing and Education Technology Journal, 3* (2), 33-47.

Martanti, A. P., Hardyanto, W., Sopyan, A. (2013). Pengembangan media animasi dua dimensi berbasis scratch materi teori kinetik gas untuk meningkatkan pemahaman konsep siswa SMA. *Unnes Physics Education Journal*, *2* (2), 20-25.

Marpaung, H. F., Supriadi, A., & Nugraha, T. (2020). Development of attitude instrument assessment in physical education learning for Tanjung Balai, Islamic School. In *1st Unimed International Conference on Sport Science (UnICoSS 2019)*, 182-184). Atlantis Press.

Martoredjo, N. T. (2023). Social media as a learning tool in the digital age: A review. *Procedia Computer Science*, *227*, 534-539.

Maulina, U., & Pahamzah, J. (2019). Attractive learning media to cope with students' speaking skills in the industry 4.0 using Sparkol Videoscribe. *International Journal of Linguistics, Literature and Translation (IJLLT), 2*(5), 132-140.

Muna, I. A. (2017). Model pembelajaran POE (predict-observe-explain) dalam meningkatkan pemahaman konsep dan keterampilan proses IPA. *El-Wasathiya: Jurnal Studi Agama*, *5*(1), 73-92.

Ningrum, N. I., Akhdinirwanto, R. W., Fay,aryantu, S. D., & Kurniaan, E. S. (2023). Pengembangan media pembelajaran fisika berbantuan scratch untuk meningkatkan kemampuan problem solving peserta didik. *Jurnal Pendidikan Fisika dan Sains, 6* (1), 32-41

Nisa, A. I., Abdullah, R., & Wardani, R. K. (2022). Studi literatur : penggunaan media scratch terhadap minat belajar dan kemampuan berpikir kreatif matematis siswa. *Jurnal Prosandika, 4*(1), 257-264.

Novitasari, N. M. (2016). Analisis miskonsepsi fisika siswa kelas X MAN 1 (model) lubuklinggau tahun pelajaran 2015/2016 pada pokok bahasan kinematika gerak lurus. *STKIP PGRI Lubuklinggau. Skripsi tidak diterbitkan. 1*, 72-76.

Planinic, M., Ivanjek, L., Susac, A., & Milin-Sipus, Z. (2013). Comparison of university students' understanding of graphs in different contexts. *Physical review special topics-Physics education research*, *9*(2), 020103.

Pratidhina, E., Yuliani, F., Wirjawan, J., Herwinarso, H., & Untung, B. (2021, August). Straight motion: A mobile application for learning linear motion. In *Proceedings of The 6th Asia-Pacific Education And Science Conference, AECon 2020, 19-20 December 2020, Purwokerto, Indonesia*.

Puspitarini, Y. D., & Hanif, M. (2019). Using learning media to increase learning motivation in elementary school. *Anatolian Journal of Education*, *4*(2), 53-60.

Qodariah, H. & Rabbani, S. (2022). Pengembangan media pembelajaran ayam MSP materi satuan panjang berbantuan aplikasi *scratch* dengan menggunakan model discovery

learning untuk meningkatkan pemahaman konsep matematika pada siswa SD kelas III. *Jurnal Profesi Pendidikan, 1* (2), 49-66.

Reflianto & Syamsuar. (2018). Pendidikan dan tantangan pembelajaran berbasis teknologi informasi di era revolusi industry 4.0. *Jurnal Ilmiah Teknologi Pendidikan, 6* (2), 1-13.

Sastradika, D., Iskandar, I., Syefrinando, B., & Shulman, F. (2021, April). Development of animation-based learning media to increase student's motivation in learning physics. In *Journal of Physics: Conference Series* (Vol. 1869, No. 1, p. 012180). IOP Publishing.

Setiyani, Waluya, S. B., Sukestiyarno, Y. L., & Cahyono, A. N. (2022). Perancangan e-modul menggunakan aplikasi kvisoft flipbook berbasis kemampuan berpikir kreatif matematis untuk sekolah menengah pertama. *Jurnal Teknologi Mobile Interaktif, 16*(4), 116-136.

Sudarma, Tegeh, & Prabawa. (2015). *Desain pesan kajian analitis desain visual teks dan image.* Yogyakarta: Graha Ilmu.

Sukadi, E., & Khaerul, M. (2020). Pengembangan LKS berbasis POE terhadap pemahaman konsep siswa SMA kelas X pokok bahasan gerak lurus. *Jurnal Pendidikan Informatika dan Sains, 9*(2), 90-102.

Sutarno, E., & Mukhidin. (2013). Pengembangan model pembelajaran berbasis multimedia interaktif pengukuran untuk meningkatkan hasil dan kemandirian belajar siswa SMP di kota Bandung. *Jurnal Pendidikan Teknologi dan Kejuruan, 21*(3), 203 218.

Sutopo, H. (2008). Pengembangan bahan ajar berbasis multimedia.

Umamah, N., & Mahmudi, K. (2020, May). Development of augmented reality in biotechnology processes as a supporting media for science learning modules in elementary schools. *IOP Conference Series: Earth and Environmental Science*, 485(1), 012069. IOP Publishing.

Widiyasanti, M., & Ayriza, Y. (2018). Pengembangan media video animasi untuk meningkatkan motivasi belajar dan karakter tanggung jawab siswa kelas V. *Jurnal Pendidikan Karakter, 8*(1).

Yolanda, Y. (2017). Remediasi miskonsepsi kinematika gerak lurus dengan pendekatan STAD. *SPEJ: Science and Physic Education Journal, 1*(1), 39-48.

Yuliyanti, R., & Mintohari. (2021). Pengembangan media video pembelajaran IPA materi siklus air pada peserta didik kelas V sekolah dasar. *Jurnal JPGSD, 9*(3).