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Enhancing Computational Thinking Skills Through Physics-Based Worksheet in Linear Motion

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Abstract
The physics knowledge consists of many concepts and principles that are generally very abstract. Learning activities should help students understand the concepts by performing a series of activities themself. One of the required thinking skills in the 21st century is Computational Thinking Skills. Computational Thinking is the thinking process required in formulating problems and solutions. This study aims to develop a valid student worksheet and describe the students' response to it. In this research, the development of Computational Thinking-based student worksheet was carried out to be used in Junior High School science learning. Validation was carried out by media experts and subject matter experts. The results from the media experts were a score of 10.65 with an average of 3.55 from a scale of 4.0. While the results from subject matter experts were a score of 3.80 from a scale of 4.0. It can be concluded that the student worksheet received good and reliable categories. The effectiveness test on four students showed an average score of 7.25 in active learning style; an average score of 16.5 in reflective learning style; an average score of 12 in theoretical learning style; and an average score of 12.25 in pragmatic learning style. From these scores, it can be concluded that the dominant learning style of the four students who acted as respondents after following learning using the student worksheet is reflective learning, where students who like to consider experiences and observe learning materials from different perspectives.

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1. Introduction

The study of physics involves many abstract concepts and principles that can be difficult for students to understand. Most students struggle with grasping the various concepts and principles of physics because they are expected to understand the knowledge accurately. Learning activities should help students understand concepts by engaging in a series of activities that allow them to discover the concepts taught. The learning process can actually develop 21st century skills such as critical thinking and problem-solving skills. One of the critical thinking skills required in the 21st century is computational thinking skills [1]. Computational thinking is the process of thinking required in formulating problems and their solutions. These solutions can then become effective information processors in solving problems [2].

The Covid-19 pandemic has an impact on education, social life and mental health of students [3]. A significant impact on education, learning activities cannot be carried out as usual, either in terms of time or process. The availability of virtual laboratories can be a solution for educators to continue to carry out meaningful learning amidst the various limitations during the current pandemic situation. Linear motion is one of the motion phenomena frequently encountered in daily life. The subject of linear motion is also one of the interesting physics subjects to be studied in junior high school. Simple analysis of the phenomena of linear motion can provide a sense and help students discover and understand the concept of straight motion.

Previous research on how are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theorethical overview, shows that the result of critical thinking skills of the students in the inquiry - discovery class was higher than that of the conventional learning class [4]. Another research on Analysis of the relation between computational thinking skills and various variables with the structural equation model shows that computational thinking skill was highly predicted by variables, respectively; "thinking styles, academic success in mathematic class, attitude against mathematic class" [5]. A research on assessing computational thinking: A systematic review of empirical studies results indicate that more CT assessments are needed for high school, college students, and teacher professional development programs. On the other side, most CT assessments focus on students' programming or computing skills [6].

In this research, a computational thinking-based student worksheet is developed to be used in junior high school science learning. The aim of this research is to develop a valid student worksheet and to describe the response of students to the worksheet. The integration of physics simulation into educational activities has the potential to enhance students' computational thinking skills [7]. Computational thinking involves problem-solving, pattern recognition, and algorithmic thinking, which are all skills that can be developed through the use of physics simulations. By simulating real-world physical situations, students are able to engage in hands-on experimentation and observation, which can help them to develop a deeper understanding of physical concepts [8]. Moreover, by manipulating variables within the simulation, students can see the immediate impact of their changes, which can help them to develop their problem-solving and algorithmic thinking skills.

Physics simulations can provide students with the opportunity to test their hypotheses and make predictions about the outcome of physical events. This helps students to develop their critical thinking skills, as they must evaluate the accuracy of their predictions and revise their understanding of physical concepts as needed. Moreover, physics simulations can be designed to allow students to explore and discover new physical phenomena, which can further enhance their computational thinking skills. By exploring the simulations in their own way, students are able to engage in creative problem-solving and develop their ability to think outside the box. Physics simulations have the potential to significantly enhance students' computational thinking skills. By providing students with hands-on experimentation and observation, simulations can help students to develop a deeper understanding of physical concepts, problem-solving skills, algorithmic thinking, critical thinking, and creativity. This research aims to develop a valid student worksheet and describe the students' response and designed to guide students in formulating problems and finding solutions

2. Methods

The research design is adapted from the ADDIE research and development (R&D) method, consisting of five phases: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation [9] [10]. However, in this study, the development phase will be limited to the development phase (Development) due to time constraints in conducting the research.

The sample in this research is 4 students in grade 8 at SMP Muhammadiyah 1 Alternatif in Magelang. The sample was taken using the Probability Sampling-Simple Random Sampling technique, which involves randomly selecting members from the population. Data was obtained from a questionnaire that included validation sheets and student response sheets. The validation sheets included material and media expert validation sheets, while the student response questionnaire was adapted from the Honey-Alonso Questionnaire of Learning Styles (CHEA Questionnaire).

Data analysis was carried out through validity and reliability tests for the validation questionnaire data and a learning style analysis for the students' response to the worksheet. The dominant learning style among students includes active, reflective, theoretical, and pragmatic learning styles. The dominant learning style reflects the characteristics of the students. Active learning style emphasizes specific experiences, reflecting students who are always involved and without prejudice in new experiences. Reflective learning style emphasizes reflective observation, reflecting students who enjoy considering experiences and observing them from different perspectives. Theoretical learning style emphasizes abstract conceptualization, reflecting students who approach problems in a step-by-step logical process, and the pragmatic learning style emphasizes active experimentation, reflecting students who act quickly and confidently on ideas and projects that are interesting to them.

3. Results and Discussion

Science learning, especially Physics that is interesting and fun for students, is one of the keys to the success of the learning process. Students who like certain subjects will more easily accept the lessons and information conveyed by the teacher properly. One way is to present a variety of experimental and practicum activities, both directly and with the help of simulation tools.

In this study, researchers utilized simulation media which can be accessed via https://www.vascak.cz/physicsanimations.php?l=en. The display/interface of the simulation can be shown in Figure 1.

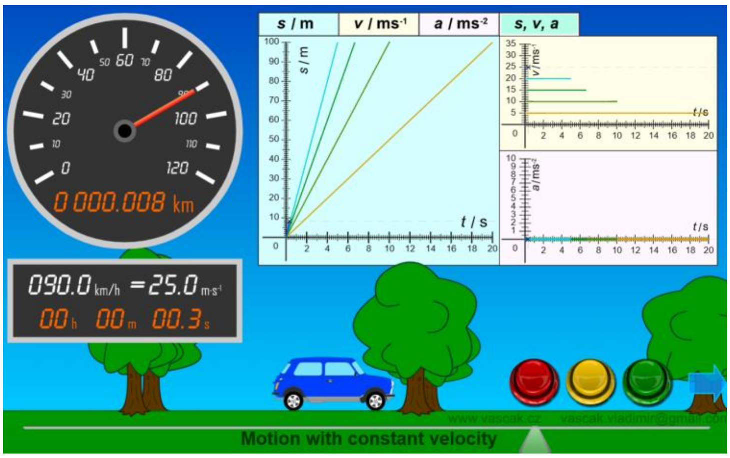

Figure 1. Linear Motion Simulation

Figure 2. Analysing the Traffict Phenomena From a Video

An example of the application (contextual) of linear motion in everyday life which is applied to worksheets connecting the daily activity to the learning by video analyzing of traffic phenomena on linear motion physics material shown in Figure 2.

The data analysis based on the validation conducted by media and subject matter experts showed that the student worksheet received a good and reliable rating. The media expert's results showed a score of 10.65 with an average of 3.55 out of 4.0, while the subject matter expert's results showed a score of 3.80 out of 4.0. The data in the table shows the scores of four students (DA, MR, NR, and PA) in the learning activity using the worksheet. The scores are given based on four learning styles, which are active, reflective, theoretical, and pragmatic. The scores were collected to determine the effectiveness of the learning activity in enhancing the students' computational thinking skills. Based on the data, the average score for the active learning style is 7.25, or 36% of the maximum score. For the reflective learning style, the average score is 16.5, or 83% of the maximum score. Meanwhile, the average scores for the theoretical and pragmatic learning styles are 12 and 12.25, respectively, which are 60% and 61% of the maximum score. Based on the finding data, the worksheet validation result from media and subject experts is shown by Figure 3.

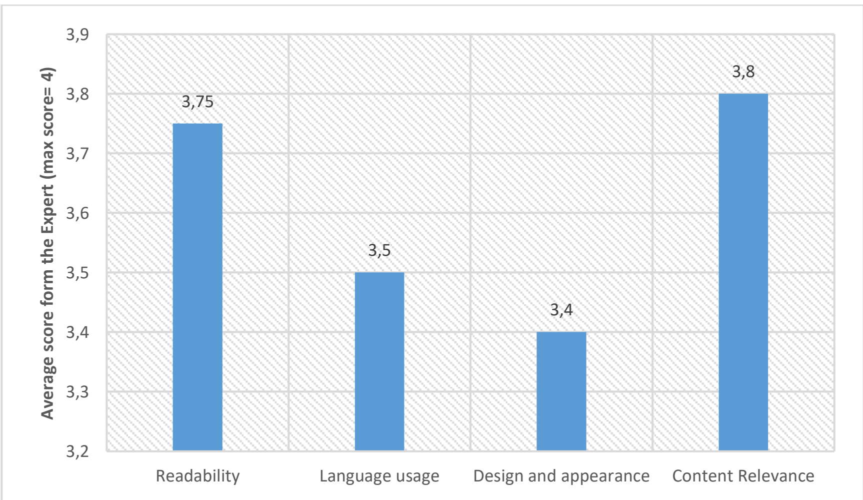

Figure 3. Validation Result

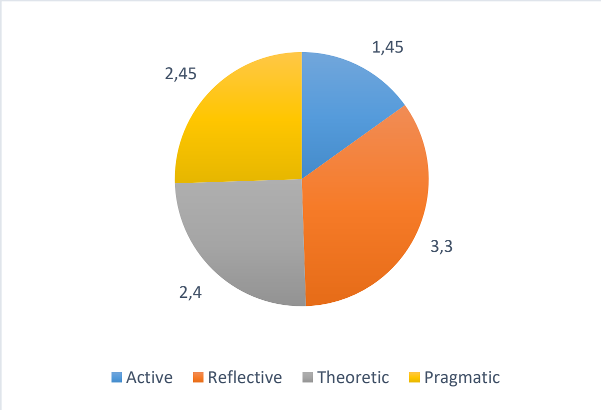

Figure 4. Student Response

Figure 4 shows the student response toward worksheet in four aspects: actice, reflective, theoretic, and pracmatics. From the analysis of the data, it can be concluded that the students who participated in the learning activity have a dominant reflective learning style, with an average score of 16.5. This means that the students tend to consider their experiences and observe the learning materials from different perspectives. On the other hand, the active and pragmatic learning styles have relatively lower average scores compared to the reflective and theoretical learning styles. This results of the data analysis are based on a small sample size of only four students. Further studies with a larger sample size would be necessary to confirm the effectiveness of worksheet in enhancing the students' learning styles and computational thinking skills [11].

This data supports the idea of multiple intelligences and the idea that students have different learning styles, which can be visual, auditory, kinesthetic, or a combination of these. According to Howard Gardner's theory of multiple intelligences, students can learn better through the use of their preferred learning style. By using the worksheet, the students are able to learn in a way that suits their learning style and preferences, resulting in a more effective and enjoyable learning experience. Additionally, the data supports Vygotsky's Social Development theory, as the students are encouraged to reflect on their experiences and consider different perspectives, allowing them to build their understanding through social interactions and collaboration with their peers.

The component of physics simulation that gives substantial influence to the enhancement of computational thinking skills is the modeling component. This component involves representing real-world phenomena through mathematical models, which can then be simulated using computational tools. Students are able to develop important problem-solving skills, such as breaking down complex problems into smaller, more manageable parts, and using abstraction and generalization to find patterns and make predictions [12] [13]. Additionally, the modeling component of physics simulation also provides students with the opportunity to develop important critical thinking skills, such as evaluating the validity of models and predictions, and making modifications to improve accuracy [14]. This process of iteratively testing and refining models helps students develop an understanding of the scientific method and the importance of experimentation and data analysis.The modeling component of physics simulation can also promote the development of collaboration and communication skills, as students often work in groups to develop and test models, and must be able to effectively communicate their findings and insights to one another [15]. These skills are crucial for success in many fields, including engineering, computer science, and data analysis.

Overall, the modeling component of physics simulation provides a rich and engaging learning environment that can help students develop a range of important skills and competencies, including computational thinking, problem-solving, critical thinking, experimentation, collaboration, and communication. In the context of physics simulation, media theory, and communication theory can play an important role in enhancing computational thinking skills. According to media theory, the design and implementation of educational media, including physics simulations, must take into account the characteristics and capabilities of the medium in order to effectively convey the intended learning objectives [16] [17]. The design of the physics simulation should consider the visual and auditory elements, interactivity, and the ease of use to ensure that students can effectively engage with the simulation and improve their computational thinking skills.

In addition, communication theory highlights the importance of effective feedback and interaction in the learning process. Physics simulations can provide students with immediate feedback on their actions, allowing them to reflect on their understanding and adjust their thinking accordingly. Furthermore, simulations can also facilitate interaction between students and teachers, allowing for a more dynamic and engaging learning experience. By considering the principles of media and communication theory in the design and implementation of physics simulations, educators can create more effective educational tools that can help students improve their computational thinking skills.

There are several problems that may prevent the implementation of using physics simulation to enhance computational thinking skills, both from the teacher and student sides. From the teacher's side, the following obstacles might arise: (1) Lack of training and knowledge in using physics simulation software: Many teachers may not be familiar with the use of physics simulation software and may need training on how to use the software and integrate it into their teaching. (2) Limited access to technology: Some schools may not have the necessary hardware or software to run physics simulation software. (3) Time constraints: Preparing and conducting lessons using physics simulation software may require more time and preparation compared to traditional methods. (4) Resistance to change: Some teachers may be resistant to using new technology and methods in their teaching, particularly if they have been using traditional methods for a long time. This is inline with [18] is an educational physics laboratory in mobile versus room scale virtual reality-a comparative study; [19] about teaching and learning physics using 3D virtual learning environment to combined virtual reality and virtual laboratory in secondary school.

Physics simulation enhance some students ability, as (1) Lack of familiarity with technology: Some students may not have previous exposure to technology or may not have the technical skills to use physics simulation software. (2) Limited motivation: Students may not be motivated to use technology in their learning if they are not interested in physics or if they find the software challenging to use. (3) Poor infrastructure: Some students may not have access to technology or the internet at home, making it difficult for them to complete homework assignments or practice using the software.

To overcome these problems, it is important to provide training and support to teachers and students, to ensure that they have the necessary skills and resources to effectively implement physics simulation in their teaching and learning. Additionally, creating a positive and supportive learning environment, that values the use of technology and encourages experimentation, can also help to increase student motivation and engagement.

4. Conclusion

The study of the effectiveness of the Student Worksheet based on Computational Thinking was carried out and analyzed by media and material experts. The results of the media expert were a score of 10.65 with an average of 3.55 out of 4.0, while the results of the material expert were a score of 3.80 out of 4.0. These results indicate that the worksheet is a good and reliable tool for learning. The effectiveness of the worksheet was also tested on four students and the results showed that the dominant learning style among the students after using the worksheet was reflective learning style, with an average score of 16.5 and a percentage of 86%. This indicates that students who prefer to consider their experiences and observe the learning material from different perspectives tend to benefit more from the worksheet. It was found that the physics simulation component of the worksheet has a substantial influence on the enhancement of computational thinking skills. This is because it allows students to apply their knowledge of physics concepts in a practical and interactive manner, promoting problem-solving and critical thinking skills. However, incorporating media and communication theories into the explanation would provide a more complete understanding of the effectiveness of the worksheet in promoting computational thinking skills. The results of the study support the effectiveness of the worksheet as a tool for learning and the development of computational thinking skills. Further research can be carried out to explore the potential impact of media and communication theories on the effectiveness of the worksheet.

References

[1] National Science Teacher Association, "NSTA position statement: Quality science education and 21st-century skill," *Sci. Educ.*, no. Windschitl pp. 1–4, 2009.

[2] J. M. Wing, "Computational Thinking," *Commun. ACM*, vol. 49, no. 3, pp. 33–35, 2006.

[3] K. Chaturvedi, D. K. Vishwakarma, and N. Singh, "COVID-19 and its impact on education, social life and mental health of students: A survey," *Child. Youth Serv. Rev.*, vol. 121, p. 105866, 2021.

[4] W. Wartono, M. N. Hudha, and J. R. Batlolona, "How are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theorethical overview?," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 14, no. 2, pp. 691–697. 2018.

[5] H. Y. Durak and M. Saritepeci, "Analysis of the relation between computational thinking skills and various variables with the structural equation model," *Comput. Educ.*, vol. 116, pp. 191–202, 2018.

[6] X. Tang, Y. Yin, Q. Lin, R. Hadad, and X. Zhai, "Assessing computational thinking: A systematic review of empirical studies," *Comput. Educ.*, vol. 148, p. 103798, 2020.

[7] K. O. V.-C. Yailem Arencibia Rodríguez del Rey, Isabel Nissandra Cawanga Cambinda, Claudia Deco, Cristina Bender, Raidell Avello-Martínez, "Developing computational thinking with a module of solved problems," *Comput. Appl. Eng. Educ.*, vol. 29, no. 3, pp. 506–516, 2021.

[8] C. Gan *et al.*, "ThreeDWorld: A Platform for Interactive Multi-Modal Physical Simulation," no. NeurIPS. pp. 1–23. 2020.

[9] B. A. Pribadi, *Model Desain Sistem Pembelajaran*. Jakarta: PT. Dian Rakyat, 2010.

[10] Sugiyono, *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2015.

[11] V. Fornons, R. Palau, and R. Santiago, "Secondary School Students' Perception According to their Learning Style of A Mathematics Flipped Classroom," *J. Technol. Sci. Educ.*, vol. 11, no. 2, pp. 227–244, 2021, doi: 10.3926/JOTSE.1092. 2021.

[12] Eguchi, Amy. "Computational thinking with educational robotics." *Society for Information Technology & Teacher Education International Conference*. Association for the Advancement of Computing in Education (AACE), 2016.

[13] Rich, Kathryn M., Aman Yadav, and Christina V. Schwarz. "Computational thinking, mathematics, and science: Elementary teachers' perspectives on integration." *Journal of Technology and Teacher Education* vol. 27, no .2, pp. 165-205. 2019.

[14] Silva, Ricardo, et al. "Fostering computational thinking skills: A didactic proposal for elementary school grades." *Education Sciences* vol. 11 no. 9 pp. 518. 2021.

[15] Arista, Fitra Suci, and Heru Kuswanto. "Virtual Physics Laboratory Application Based on the Android Smartphone to Improve Learning Independence and Conceptual Understanding." *International Journal of Instruction.* vol 11 no.1 pp: 1-16. 2018.

[16] Siahaan, P., et al. "Improving students' science process skills through simple computer simulations on linear motion conceptions." *Journal of Physics: Conference Series*.. IOP Publishing, Vol. 812. No. 1 2017.

[17] Pirker, Johanna, et al. "An educational physics laboratory in mobile versus room scale virtual reality-a comparative study." *Online Engineering & Internet of Things: Proceedings of the 14th International Conference on Remote Engineering and Virtual Instrumentation REV 2017, held 15-17 March 2017, Columbia University, New York, USA*. Springer International Publishing, 2018.

[18] Bogusevschi, Diana, Cristina Muntean, and Gabriel-Miro Muntean. "Teaching and learning physics using 3D virtual learning environment: A case study of combined virtual reality and virtual laboratory in secondary school." *Journal of Computers in Mathematics and Science Teaching*. Vol. 39, No.1, pp. 5-18, 2020.