Received : 26 June 2023
Revised : 12 December 2023
Accepted : 26 December 2023
Online : 30 December 2023
Published: 31 December 2023

DOI: doi.org/10.21009/1.09205

Development of Physics Worksheet based on STEM integrating Engineering Design Process (EDP) through Guided Inquiry Model to Improve Students' Critical Thinking

M. Syukri[1,a)], F. Herliana[1,b)], Maryono[1,c)], Ngadimin[1,d)], W. Artika[2,e)]

[1]*Physics Education Department, Universitas Syiah Kuala, Tgk. Hasan Krueng Kalee Street, Banda Aceh 23111, Indonesia*
[2]*Biology Education Department, Universitas Syiah Kuala, Tgk. Hasan Krueng Kalee Street, Banda Aceh 23111, Indonesia*

✉: [a)]syukri.physics@usk.ac.id, [b)]fitriaherliana@usk.ac.id, [c)]maryonomujahid@gmail.com, [d)]ngadimin_ws@usk.ac.id, [e)]wartika@usk.ac.id

Abstract

This study aimed to develop a physics worksheet based on STEM integrating Engineering Design Process (EDP) through the guided inquiry model to improve students' critical thinking in learning physics. The research approach used R&D using the ADDIE model, namely: 1) analysis, 2) design, 3) development, 4) implementation, and 5) evaluation. The data collected was in the form of worksheet eligibility data and critical thinking instruments by experts, and response questionnaires given to five physics teachers at a senior high school in Kutacane. Data analysis using percentage descriptive analysis. The results of the worksheet eligibility test by experts show a percentage score of 79.5%, which is the feasible category, and a critical thinking instrument score of 83.3%, which is the very feasible category. Teachers' response results show the percentage of suitability indicators of the worksheet with the EDP model step through the guided inquiry model was 91.6% and the EDP model step suitability indicator with critical thinking ability was 93.6%, both of which were included in very valid qualifications. It could be concluded that a worksheet based on STEM integrating the Engineering Design Process (EDP) through the Guided Inquiry Model is appropriate for use to improve students' critical thinking skills in learning physics.

Keywords: worksheet, STEM, EDP, critical thinking

INTRODUCTION

The process of education has the ability to shape the way students think. According to Article 3 of Law No. 20 of 2003, which pertains to the national education system, the main purpose of national education is to foster students' abilities and cultivate a sense of honorable national identity and civilization within the framework of national life. This aims to unlock the potential of students to become individuals who have faith in and show reverence towards God almighty (Alawiyah 2017). Developing the potential of students in the 21st century so they can compete in the world of work is emphasized on 3 types of competencies, namely: 1) learning skills (creativity and innovation, critical thinking, and problem-solving; communication and collaboration); 2) literacy skills (information literacy; media literacy; ICT literacy), and 3) life skills (flexibility and adaptability; initiative and self-

direction; social and intercultural skills; productivity and accountability; leadership and responsibility) (González-Pérez and Ramírez-Montoya 2022)

The fact is that currently there are still many students in Indonesia who are low in terms of critical, creative thinking skills, and scientific process abilities. The results of PISA (Program for International Student Assessment) and TIMSS (Trend in Mathematics and Science Study) show that students' thinking skills are still low. According to the TIMSS (Trend in Mathematics and Science Study) survey by the IEA (The International Association for The Evaluation of Educational Achievement) in 2015, Indonesia's position in science is ranked 44th out of 47 countries with an average score of 397. Low scientific ability is also seen in the PISA (Program for International Student Assessment) study conducted by the OECD (Organization for Economic Cooperation and Development) Indonesia is ranked 73 out of 75 countries (Schleicher 2021). The data above shows that Indonesian students' three 21st-century competencies are still low compared to other countries. The formation of these three competencies in students is interrelated with one another. Fostering critical thinking in students is a highly important skill to cultivate. It is vital because this empowers them to independently assess, analyze, and draw logical conclusions from information. This, in turn, prepares them for making informed decisions and solving problems effectively. A learning process that involves students directly in critical thinking is very necessary in its implementation (Chalkiadaki 2018) It is crucial to apply an instructional approach that promotes the cultivation of critical thinking skills during the learning process.

The STEM approach refers to an educational method that combines four main disciplines: science, technology, engineering, and mathematics. This approach centers on applying these subjects to address practical challenges in daily life (Syukri et al. 2021). By integrating the four disciplines in the learning process, STEM can develop 21st-century skills competencies because the STEM learning environment provides opportunities for students to build their understanding directly with a student-centered approach. (Krüger Mariano and Chiappe 2021; Hacioğlu 2021). The integration of STEM in learning can increase student activity and creativity which is quite high and students can understand concepts well. Learning that integrates the STEM approach requires students to analyze the engineering of a technology by using various representations so that students will understand the concept well and students are accustomed to using various representations which has implications for increasing students' multi-representational skills (Mulyana et al. 2018). The Engineering Design Process (EDP) is a systematic approach to problem-solving, where a concrete and functional creation is developed through a series of step-by-step procedures. This is a problem-solving strategy used in STEM-based education and in real-world engineering (Linh 2021). The EDP is employed to foster a problem-solving learning environment, encouraging students to envision solutions for design challenges, gather relevant information, and address real-world problems through an engineering design process. By incorporating EDP into STEM education, students have the opportunity to enhance their critical thinking and problem-solving abilities while participating in inquiry-based learning approach (Lin et al. 2021).

A learning approach requires a learning model in the application of the process because the learning model assists in the learning process by providing a clear and structured frame or plan for designing and implementing effective learning (Pajrin et al. 2019). The learning model provides clear directions and guidelines for teachers in designing and implementing effective and meaningful learning for students. STEM is a learning approach that enables student-centered teaching and learning processes and involves inquiry processes in problem-solving (Wilujeng and Zulaikha 2023). The inquiry process in the STEM approach can be structured using the guided inquiry learning model. Guided Inquiry is an educational approach that emphasizes the active involvement of students in the learning process. Through the application of this model, students are provided with the chance to independently develop procedures, analyze results, and draw conclusions. Meanwhile, the teacher takes on the role of a facilitator, assisting in the selection of topics, questions, and supporting materials (Kuhlthau et al. 2015). The characteristics of the guided inquiry model are in line with the STEM approach, allowing the guided inquiry model to be integrated with the STEM approach in the learning process to improve students' 21st-century competencies, one of which is critical thinking skills (Sutoyo et al. 2019). Nevertheless, cultivating critical thinking abilities using STEM approach poses a challenge. Obstacles to teaching critical thinking that were reported ranged from challenges related to teacher work requirements, student habits, and what is expected of students in the future (Dwyer 2023). In STEM-

based learning, teachers require support from instructional tools or appropriate learning resources to transform students' learning habits that do not foster critical thinking skills (Evangelisto 2023). The instructional tools that must be prepared according Permendikbud No. 22 of 2016 is included the syllabus, lesson plans, and worksheets (Permendikbud No. 22., 2016). The worksheet is a student worksheet that includes student activities in the learning process. Active and interesting worksheets can make students more enthusiastic about participating in the learning process (Furqoniyah et al. 2022). In addition, worksheet which has been developed based on STEM can improve students' critical thinking skills (Hartini et al. 2020; Syukri et al. 2021).

Based on these problems, efforts to overcome obstacles experienced to develop critical thinking skills, Worksheet based STEM integrating Engineering Design Process (EDP) through Guided Inquiry Model to Improve Students' Critical Thinking needs to be developed. It is expected that students will be able to build their knowledge through an active learning process and have an impact on increasing critical thinking skills in learning physics.

METHODS

The type of research used is R&D (Research and Development) with the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate) (Sugiyono 2015). However, due to time and cost limitations in the research process, it can only be carried out until the development stage. The instruments used in this study were worksheet validation, critical thinking skills validation, and teacher response questionnaire.

The worksheet validation instrument tests the suitability of the worksheet with the lesson plan and STEM aspects. This instrument refers to the BSNP assessment criteria for the development of LKPD, namely content feasibility, presentation feasibility, language feasibility, and contextual assessment (Poerwanti 2008). Data collection used a questionnaire with a Likert scale from 1-5 with a choice of answers from strongly agree to strongly disagree. While the validation instrument for critical thinking skills refers to 5 critical thinking skills, namely Elementary Clarification, Basic Support, Inference, Advance Clarification, Strategy and Tactics (Ennis 2015). The teacher's response instrument tested the suitability of the worksheet with guided inquiry model steps and STEM aspects, as well as the suitability of the worksheet using EDP steps with aspects of critical thinking skills. Validation is carried out by expert validators in their fields, there are expert in the field of STEM and expert in the field of lesson planning. The data generated from this study is the result of expert validation for worksheets and critical thinking skills, as well as teacher responses to EDP-integrated STEM-based worksheets through guided inquiry models in physics learning, especially work and energy material. The subjects in this study were class X physics teachers at SMA Negeri 1 Kutacane. Teacher response questionnaires were given to physics teachers at SMAN Negeri 1 Kutacane as practitioners. Data analysis in this study used percentage analysis which was then interpreted using a questionnaire score interpretation table (Sudjana 2005).

TABLE 1. Interpretation table of expert validation test questionnaire results

Range of score	Qualification
82% < x < 100%	Highly Valid
63% < x < 81%	Valid
44% < x < 62%	Not Valid enough
25% < x < 43%	Not Valid

RESULTS AND DISCUSSION

The results of this study indicate that the Worksheet based on STEM integrating Engineering Design Process (EDP) through the Guided Inquiry Model that has been developed is feasible to use to improve student's critical thinking skills. These results were obtained through several processes that have been carried out, namely analysis, design, and development. At the analysis stage, observations of learning activities and direct interviews were carried out with teachers and students at SMAN 1 Kutacane. The results of this analysis stage show that physics learning activities at SMAN 1 Kutacane are still teacher-centered so student learning activities are very minimal. In addition, the learning process is not equipped with worksheets that can guide student learning activities. Therefore, the learning process

takes place in one direction where there is a lack of interaction between students and teachers as well as between fellow students. This causes the learning process to tend to be boring so that students cannot develop their thinking skills, including critical thinking skills. Critical thinking skills are strongly influenced by student learning activities (Shcheglova et al. 2019). If students are directly involved in the learning process, students can build their understanding so that their critical thinking skills can improve (Lv et al. 2022). Therefore, it is necessary to develop a Worksheet based on STEM integrating Engineering Design Process (EDP) through the Guided Inquiry Model to support the physics learning process so that the learning process takes place in two directions and students are more active in learning. With the Worksheet based on STEM integrating Engineering Design Process (EDP) through the Guided Inquiry Model, it is expected that students can be active in the learning process and their critical thinking skills can improve.

In the design phase compile a draft worksheet containing the guided inquiry steps of the STEM-based integrated EDP model. The preparation of the worksheet is carried out on the basis of elements, there are 1) cover, 2) worksheet identity, 3) worksheet learning objectives, 4) work instructions, 5) worksheet activities, 6) conclusions (Furqoniyah et al. 2022). This worksheet was prepared using the guided inquiry model steps adapted to the EDP steps, where the Engineering Design Process (EDP) is an engineering aspect that is always integrated and also a characteristic of learning science (physics) based on the STEM approach (Sudjana 2005). The EDP follows a fundamental structure of analysis, synthesis, and evaluation, which necessitates students, as designers, to progress through the stages of problem analysis, combining various sources and information to devise solutions, and then assessing those solutions. The five steps of the engineering design process are; ask, imagine, plan, create, and improve (Shahali et al. 2016; Syukri 2020). The five EDP steps are implemented through the guided inquiry model steps as follows: 1) formulating a problem, 2) making a hypothesis, 3) designing an experiment, 4) conducting an experiment and collecting data, 5) analyzing the data, and 6) making a conclusion (Kuhlthau et al. 2015).

In the early part of this worksheet, students are given problems by carrying out simple experiments related to the concepts of work and energy on a simple roller coaster. This section can be seen in the FIGURE 1.

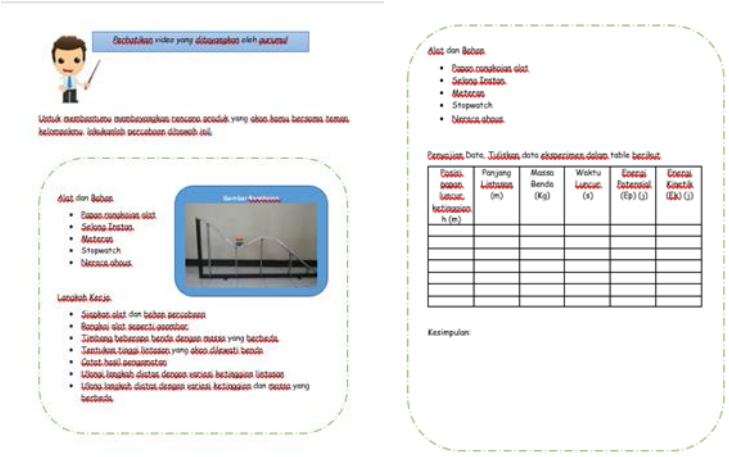

FIGURE 1. Step of "Ask" through formulating a problem

In this section, the "ask" step of the EDP model is applied through the activity of formulating problems from the guided inquiry model where students have the chance to investigate problems and apply their knowledge of scientific concepts gained from experiments to create their most effective products (Syukri et al. 2018). By conducting this simple experiment, students are given the experience of conducting simple experiments as initial knowledge regarding the concepts of work and energy, then are trained to identify things that happen in these experimental activities. With this activity, it is hoped that the indicator of "elementary clarification" of critical thinking skills can increase.

Next is the section that contains the "imagine" step of the EDP model which is integrated with the step of making a hypothesis from the guided inquiry model. In this section, Students are required to

engage in thinking and imagination to devise products that can effectively address problems by hypothesizing what concepts are needed in compiling a simple roller coaster product where this product is the application of the concepts of work and energy. In a study conducted by Maryati et al., it was shown that students' ability when imagining what was obtained from simple pictures was very low, namely only 39% (Maryati et al. 2022). This proves that students' critical thinking skills are still low so they need further training. By making a hypothesis, students are expected to be able to imagine what products can be made related to the concept of work and energy as well as indicators of "basic support" of critical thinking skills that can improve. This section of the worksheet can be seen in the FIGURE 2.

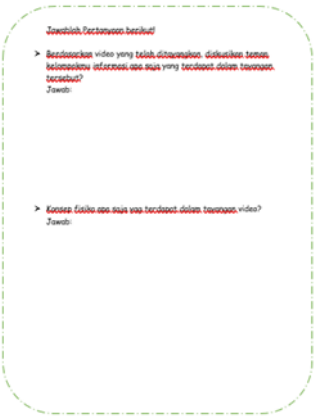

FIGURE 2. Step of "Imagine" through making a hypothesis.

Next is the section that contains the "plan" step of the EDP model through the experimental design step of the guided inquiry model. In the plan step, students design a possible solution in the form of a diagrammatic solution that they imagined in the previous activity by sequencing the experimental steps in accordance with the hypothesis that was made before. Many studies find that alignment tasks involving designing and carrying out scientific investigations improve students' critical thinking skills, including advanced clarification (Van Huynh et al. 2022). With the experimental design activities, it is expected that the "Advance Clarification" indicator of critical thinking skills can improve where implicit reasoning is greatly influenced by the experimental design activities. This section of the worksheet can be seen in the FIGURE 3.

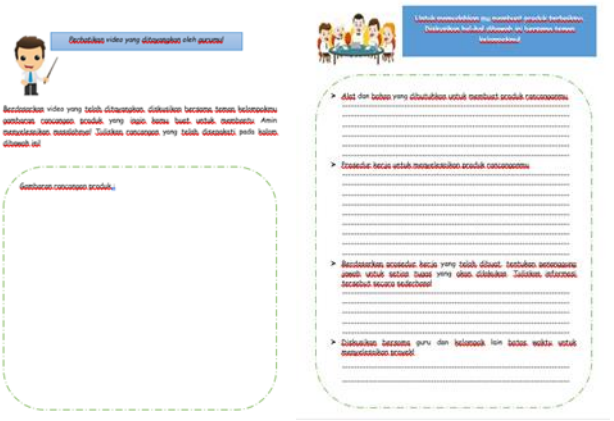

FIGURE 3. Step of "plan" through designing an experiment.

The "create" step of the EDP model is applied through the steps of conducting an experiment and collecting data from the guided inquiry model, where the student's activities develop scientific-technical products into the exact form of plans they have made to solve problems through the steps of obtaining information through experiments and conveying the results of data processing collected. By

creating a product, students can learn how to clarify the advantages of the product. These skills can help students develop their strategic and tactical abilities, which can be useful in a variety of fields (Putra et al. 2021). With this activity, it is expected that the indicator "Strategy and Tactics" of critical thinking skills can increase. This section of the worksheet can be seen in the FIGURE 4.

FIGURE 4. Step of "create" through conducting an experiment and collecting data.

The final section in this worksheet is "improve" the EDP model which is through the step of making conclusions from the guided inquiry model. In this section, With guidance from the teacher, students enhance the technical science products they have created by addressing weaknesses and deficiencies identified by their peers in other groups, leading to concluding remarks. The teacher's role as a facilitator in this section is very important to train students in drawing conclusions (Ulum et al. 2021) With this activity, it is expected that the "inference" indicator of critical thinking skills can increase. This section of the worksheet can be seen in the FIGURE 5.

FIGURE 5. Step of "improve" through drawing conclusions.

The worksheet that has been designed is then carried out by an expert validation test to test the feasibility of the worksheet that has been developed in terms of 3 aspects, namely aspects of presentation, content feasibility, and language. The results of the expert validation test show a percentage score of 79.5% which states that the Physics Worksheet based on STEM integrating Engineering Design Process (EDP) through Guided Inquiry Model has valid qualifications, in detail per aspect can be seen in FIGURE 6.

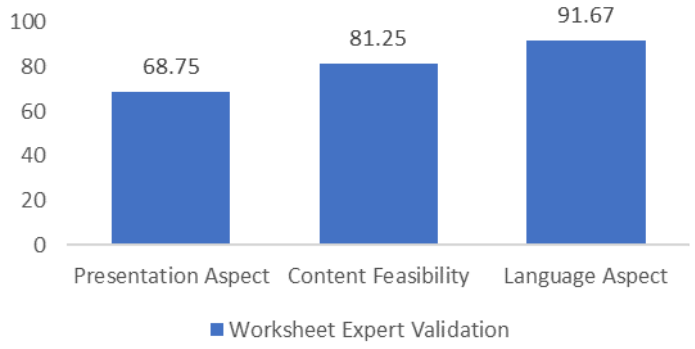

FIGURE 6. Worksheet expert validation results per aspect.

These results indicate that the worksheet has good content feasibility and language aspects because the activity steps contained in the worksheet are in accordance with the EDP Steps through the STEM-based guided inquiry model. In addition, the activities provided can also achieve competency achievement indicators because competency achievement indicators can be achieved maximally, if learning activities are clearly structured and structured according to the specific skills and knowledge reflected in the indicators (Bistari 2017) so that this worksheet can help students in the learning process using the EDP model through the STEM-based guided inquiry model. However, the presentation aspect is qualified as valid but the score is not maximized due to the lack of attractive design on the worksheet where no pictures are displayed. Worksheets only contain material explanations and instructions that students need to do so that it can reduce student motivation (Arifin and Abduh 2021) and have an impact on learning outcomes (Herliana et al. 2022). From the results of this validation, the worksheet was redeveloped by adding pictures on each page so that it can attract students' attention to learning because the presence of attractive images has a big effect on students' interest in learning (Daryanto et al. 2022).

While the critical thinking skills test instrument that has been validated by experts gets a percentage score of 83.3% with very valid qualifications. The validation of this instrument when viewed from each aspect shows that the presentation aspect has the highest score of 100% and the content eligibility aspect has the lowest score of 75%, but both are qualified as valid as shown in FIGURE 7.

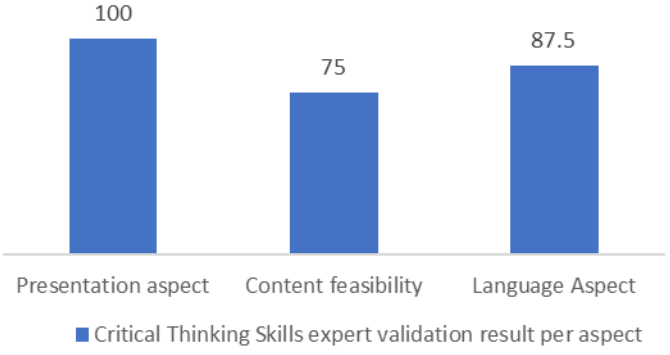

FIGURE 7. Critical Thinking skills expert validation results per aspect.

After validation by experts, 5 questions were found to be feasible out of 8 validated questions. These five questions cover aspects of critical thinking from Ennis (2002) including: elementary clarification, basic support, inference, advance clarification, strategy and tactics. In the presentation aspect, this instrument is very good because the instrument is arranged with numbering and there are clear instructions for solving the problem so that students have no difficulty understanding the instrument given. However, the content feasibility aspect of this instrument has the lowest score compared to other aspects. The expert assessed each question given in accordance with the aspects of critical thinking skills to be developed, but had not deeply measured each aspect so that the expert could not give the

maximum value. Then a practicality test was carried out for worksheets by 5 teachers at SMAN 1 Kutacane. The percentage of suitability indicators of worksheet with the EDP model step through the guided inquiry model was 91.6% as shown in FIGURE 8.

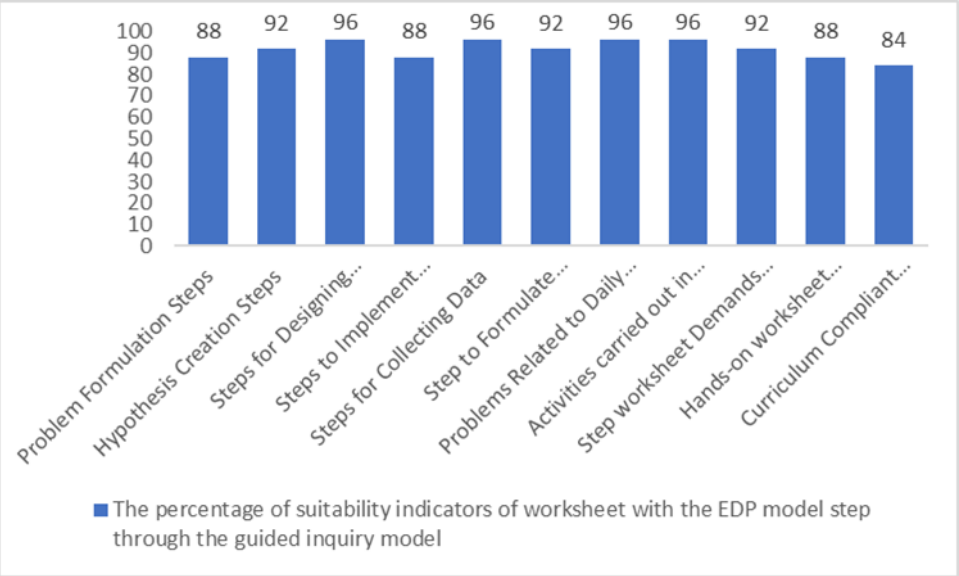

FIGURE 8. The percentage of suitability indicators of worksheet with the EDP model step through the guided inquiry model.

And the indicator of the suitability of the EDP model steps with critical thinking skills was 93.6% as shown in FIGURE 9.

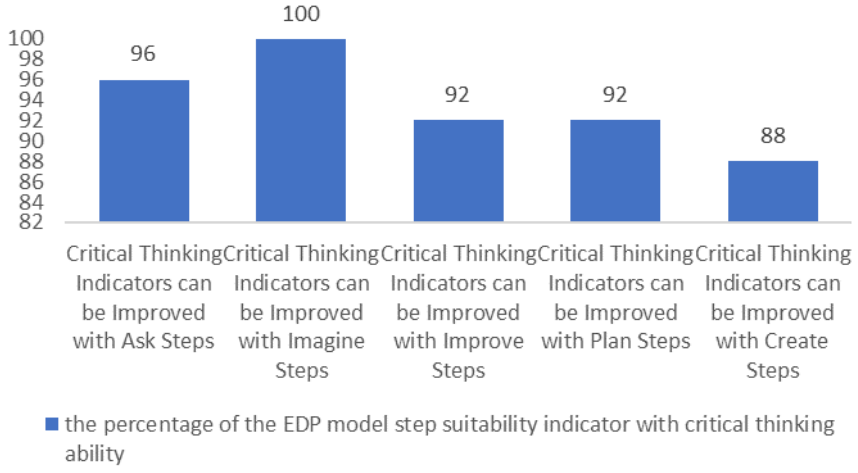

FIGURE 9. The percentage of the EDP model step suitability indicator with critical thinking ability.

Both of which were included in very valid qualifications. Agustina, NS supports the notion that teaching materials created with a foundation in STEM for elementary schools are practicable and suitable for implementation (Ulum et al. 2021). Therefore, This data shows that the Worksheet based on STEM integrating Engineering Design Process (EDP) through the Guided Inquiry Model is valid and feasible to use to increase students' critical thinking.

CONCLUSION

Based on the data from expert validation, the worksheet is considered valid with an average percentage score of 79.5%. The instrument for critical thinking skills is highly valid with an average

percentage score of 83.3%. Additionally, the teacher's feasibility test results revealed that the worksheet aligns well with the EDP steps and the indicators of critical thinking skills, indicating a high level of suitability with an average percentage score of 91.6% and the EDP model step suitability indicator with critical thinking ability was very valid qualifications with an average percentage score of 93.6%. Consequently, it can be concluded that a STEM-based worksheet that integrates the Engineering Design Process (EDP) using the Guided Inquiry Model is suitable for enhancing students' critical thinking skills in physics learning. These research findings serve as essential information for researchers and educators to develop worksheets based on STEM, integrating the EDP approach through other suitable learning models to promote students' critical thinking skills in physics education.

ACKNOWLEDGMENT

Thank you to all parties who have contributed to this research, especially LPPM at Universitas Syiah Kuala which has facilitated the implementation of this research. In addition, thanks to the physics education department, the Teacher Training and Education Faculty of Universitas Syiah Kuala, and the teachers at SMAN 1 Kutacane who were involved in this research. Hopefully, this research can be useful for various parties.

REFERENCES

Agustina, NS & Yanthi, N 2023, 'The Development of STEM-based Worksheet in Elementary School', *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 5, pp. 3839-3848.

Alawiyah, F 2017, 'Standar nasional pendidikan dasar dan menengah', *Aspirasi*, vol. 8, no. 1, pp. 81-92.

Arifin, M & Abduh, M 2021, 'Peningkatan motivasi belajar model pembelajaran blended learning', *Jurnal Basicedu*, vol. 5, no. 4, pp. 2339-2347.

Bistari, B 2017, 'Konsep dan indikator pembelajaran efektif', *Jurnal kajian pembelajaran dan keilmuan*, vol. 1, no. 2, pp. 13-20.

Chalkiadaki, A 2018, 'A systematic literature review of 21st century skills and competencies in primary education', *International Journal of Instruction*, vol. 11, no. 3, pp. 1-16.

Daryanto, J, Rukayah, R, Sularmi, S, Budiharto, T, Atmojo, IRW, Ardiansyah, R & Saputri, DY 2022, 'Meningkatkan motivasi belajar peserta didik sekolah dasar melalui pemanfaatan media lkpd interaktif berbasis liveworksheet pada masa revolusi industri 4.0', *Jurnal Pengabdian UNDIKMA*, vol. 3, no. 2, pp. 319-326.

Dwyer, CP 2023, 'An Evaluative Review of Barriers to Critical Thinking in Educational and Real-World Settings', *Journal of Intelligence*, vol. 11, no. 6, p. 105.

Ennis, RH 2015, 'Critical thinking: A streamlined conception', *In The Palgrave handbook of critical thinking in higher education*, New York: Palgrave Macmillan US, pp. 31-47.

Evangelisto, C 2023, 'Overcoming Obstacles and Finding Support for Teaching Critical Thinking in STEM Breadcrumb', *Journal of College Science Teaching*, vol. 52, no. 5.

Furqoniyah, Q, Subiki, M & Maryani, M 2022, 'Pengembangan LKPD Berbasis STEM (Science, Technology, Engineering, And Mathemathics) Dalam Pembelajaran Fisika Pemanasan Global Di SMA', *Jurnal Inovasi dan Pembelajaran Fisika*, vol. 9, no. 1, pp. 76-84.

González-Pérez, LI & Ramírez-Montoya, MS 2022, 'Components of Education 4.0 in 21st century skills frameworks: systematic review', *Sustainability*, vol. 14, no. 3, 1493.

Hacioğlu, Y 2021, 'The effect of STEM education on 21th century skills: Preservice science teachers' evaluations', *Journal of STEAM Education*, vol. 4, no. 2, pp. 140-167.

Hartini, S, Mariani, I & Sulaeman, NF 2020, 'Developing of students worksheets through STEM approach to train critical thinking skills', *In Journal of Physics: Conference Series IOP Publishing*, vol. 1567, no. 4, p. 042029.

Herliana, F, Elisa, E, Farhan, A & Astra, IM 2022, 'The Relationship of Motivation and Self-regulated Learning through Blended Learning in the Covid-19 Era', *JIPF (Jurnal Ilmu Pendidikan Fisika)*, vol. 7, no. 1, pp. 50-59.

Krüger Mariano, W & Chiappe, A 2021, '21st-century skills and their relationship to STEAM learning environments: a review'.

Kuhlthau, CC, Maniotes, LK & Caspari, AK 2015, 'Guided inquiry: Learning in the 21st century', *Bloomsbury Publishing*, USA.

Lin, KY, Wu, YT, Hsu, YT & Williams, PJ 2021, 'Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking', *International Journal of STEM Education*, vol. 8, pp. 1-15.

Linh, NQ 2021, 'Engineering design process in STEM education: an illustration with the topic, wind energy engineers', *In Journal of Physics: Conference Series IOP Publishing*, vol. 1835, no. 1, p. 012051.

Lv, S, Chen, C, Zheng, W & Zhu, Y 2022, 'The relationship between study engagement and critical thinking among higher vocational college students in China: a longitudinal study', *Psychology Research and Behavior Management*, pp. 2989-3002.

Maryati, RE, Permanasari, A & Ardianto, D 2022, 'Fluid Learning with Arduino-Based on Engineering Design Process (EDP) to Improve Student's Problem Solving Ability', *Scientiae Educatia: Jurnal Pendidikan Sains*, vol. 11, no. 2, pp. 154-162.

Mulyana, KM, Abdurrahman, A & Rosidin, U 2018, 'The implementation of science, technology, engineering, and mathematics (STEM) approach for improving multiple-representation skill of senior high school student on newton's law about motion', *Jurnal Pendidikan Fisika*, vol. 7, no. 2, pp. 69-75.

Pajrin, NAS, Asyafah, A & Anwar, S 2019, 'Studi Prosedur Penilaian Domain Afektif Oleh Guru PAI Di Smp Negeri 2 Bandung Dan Smp Salman Al-Farisi Bandung', *TARBAWY: Indonesian Journal of Islamic Education*, vol. 6, no. 2, pp. 157-175.

Permendikbud No. 22. Tahun 2016, 'Tentang Standar Proses Pendidikan Dasar dan Menengah'.

Poerwanti, E 2008, 'Standar Penilaian Badan Standar Nasional Pendidikan (BSNP)'.

Putra, PDA, Sulaeman, NF, Supeno & Wahyuni, S 2021, 'Exploring Students' Critical Thinking Skills Using the Engineering Design Process in a Physics Classroom' *The Asia-Pacific Education Researcher*, pp. 1-9.

Schleicher, A 2021, 'Learning from the Past, Looking to the Future: Excellence and Equity for all: Andreas Schleicher', OECD.

Shahali, EHM, Halim, L, Rasul, MS, Osman, K & Zulkifeli, MA 2016, 'STEM learning through engineering design: Impact on middle secondary students' interest towards STEM', *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 13, no. 5, pp. 1189-1211.

Shcheglova, I, Koreshnikova, Y & Parshina, O 2019, 'The role of engagement in the development of critical thinking in undergraduates', *Вопросы образования*, pp. 264-289.

Sudjana, N 2005, 'Metode Statistika Edisi keenam', Bandung: PT. Tarsito.

Sugiyono 2015, 'Metode Penelitian (Pendekatan Kuatitatif, Kualitatif dan R&D)', Penerbit CV. Alfabeta: Bandung.

Sutoyo, S, Azizah, U & Allamin, S 2019, 'Effectiveness of the guided inquiry model integrated with STEM to improve the student critical thinking skills in chemistry learning', *International Journal of Innovative Science and Research Technology*, vol. 4, no. 12, pp. 349-353.

Syukri, M 2020, 'Peningkatan Minat Belajar Siswa Melalui Model Pbl Berbasis Pendekatan Stem Dalam Pembelajaran Fisika', *PENCERAHAN*, vol. 14, no. 2, pp. 152-165.

Syukri, M, Halim, L, Mohtar, LE & Soewarno, S 2018, 'The impact of engineering design process in teaching and learning to enhance studentsâ€™ science problem-solving skills', *Jurnal Pendidikan IPA Indonesia*, vol. 7, no. 1, pp. 66-75.

Syukri, M, Herliana, F, Soewarno, S, Rizal, S & Halim, L 2021, 'The skills of high school physics teachers in developing STEM-based learning in K13 curriculum', *In AIP Conference Proceedings*, AIP Publishing, vol. 2320, no. 1.

Syukri, M, Maghfirah, S, Halim, A & Herliana, F 2021, 'Student responses toward worksheets based on stem approach through project-based learning model', *In Journal of Physics: Conference Series*, IOP Publishing, vol. 1882, no. 1, p. 012031.

Ulum, MB, Putra, PDA & Nuraini, L 2021, 'Identifikasi penggunaan EDP (Engineering Design Process) dalam berpikir engineer siswa SMA melalui Lembar Kerja Siswa (LKS)', *Jurnal Riset Dan Kajian Pendidikan Fisika*, vol. 8, no. 2, p. 53.

Van Huynh, C, Phan, HT, Hua, TD, Tran-Thi, TH & Tran-Chi, VL 2022, 'Relationship between the fear of missing out and loneliness among university students in COVID-19 pandemic', *Pegem Journal of Education and Instruction*, vol. 12, no. 3, pp. 44-48.

Wilujeng, I & Zulaikha, DF 2023, 'Exploring Teachers' Perspectives on Implementation of STEM-Inquiry Integrated with Disaster Mitigation', *JIPF (Jurnal Ilmu Pendidikan Fisika)*, vol. 8, no. 1, pp. 18-29.