

Development of E-Worksheet Based on STEAM-PjBL in Reaction Rate Material to Improve Creative Thinking Skills High School Student

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ABSTRACT

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The lack of creative thinking skills causes students to be less optimal in facing challenges in the era of the industrial revolution 4.0. Therefore, efforts are needed to improve students' creative thinking skills through the learning process in the classroom. This study aims to develop and determine the quality of E-Worksheet loaded with STEAM-PjBL on reaction rate material to improve students' creative thinking skills. Research conducted using 4D models (Define, Design, Development, and Disseminate). The instrument used is in the form of product quality assessment sheets and student responses. The results of the E-Worksheet assessment based on the assessment of material experts, media experts, reviewers, and student responses received an ideal percentage of 93%, 97%, 90%, and 93% in the excellent category. Based on the assessment results, the developed E-Worksheet can be used as an alternative learning medium to improve students' creative thinking skills.

Keywords: *STEAM-PjBL, Development Worksheet, Creative Thinking*

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INTRODUCTION

21st-century skills are the key to student success in facing life's challenges in the era of the industrial revolution 4.0 (Purnama & Suparman, 2020). 21st-century skills are known as 4C skills which consist of communication, collaboration, critical thinking, problem-solving skills, and creative and innovative thinking (Framework for 21st Century Learning, 2006). Students' 21st-century skills can be achieved by improving the quality of 21st-century learning (Jayadi et al., 2020). The increasing quality of 21st-century learning is influenced by the latest skills and innovations to face 21st-century learning (Mahjatia et al., 2021). However, the current 21st-century learning does not seem to provide optimal results for students, which impacts the lack of 21st-century skills students possess (Pratiwi, 2019). According to the results of the Global Creativity Index (GCI) study in 2015, one of the 21st-century skills, namely students' creative thinking skills, in Indonesia still lacks. Indonesia is ranked 115 out of 139 countries worldwide (Florida et al., 2015).

One of the government's policies was to improve 21st-century skills in students by enacting the 2013 curriculum (Andrian & Rusman, 2019). The 2013 curriculum provides opportunities for students to master the skills needed in

present and future life (Permendikbud, 2018). The 2013 curriculum is a curriculum whose implementation emphasizes more on attitude-based competencies, skills, and knowledge (Madrasah & Negeri, 2022; Refitaniza, 2022). The learning system of the 2013 curriculum is student-centered so that teachers act as facilitators in developing students' critical thinking, creative skills, and active participation in learning (Rahayu & Sutarno, 2021). The 2013 curriculum uses a scientific approach that makes it easier for students to recognize and understand the material through the scientific method (Mahjatia et al., 2021). In addition, the 2013 curriculum can also increase student creativity and learning innovation because students play a dominant role in their learning (Halek, 2019). However, the reality shows that implementing the 2013 curriculum still isn't optimal. The lack of optimal implementation of the 2013 curriculum is due to the lack of learning media available in schools (Ainurrofiq, 2020).

Teachers are required to be able to create learning media so that the learning process can take place effectively (Abdullah, 2017). Learning media is everything that is used to deliver learning material so that learning objectives can be achieved properly (Cahyono et al., 2021; Suhono et al., 2022; Tulasih et al., 2022; Hamid et al., 2020). The use of learning media can make it easier for teachers to deliver material to make it easier for students to understand (Pradilasari et al., 2019; Istanto et al., 2021; Pramesti & Amelia, 2022; Rohibni et al., 2022). In addition, learning media can also provide new knowledge and understanding to students and improve students' ability to analyze and create (Cahyadi, 2019; Nurrita, 2018). Therefore, the use of learning media is very important to improve the quality of learning to be better (Sundayana, 2016). One of the learning media that is often used in schools is the printed Student Worksheet (Noprinda & Soleh, 2019). However, school worksheet print has not been able to make students enthusiastic about learning (Sari et al., 2020). The worksheet's print is usually colorless, with few illustrations or pictures, and the questions used also do not attract students to do (Prasetia & Suparman, 2019).

Efforts to increase student enthusiasm for learning can be made by developing E-Worksheet (Junita & Yuliani, 2022). An E-worksheet is a form of systematically presenting digital teaching materials consisting of animation, images, videos, and navigation to make it easier for students to use them (Sholehah et al., 2021). Teachers can develop an E-Worksheet according to student needs in learning that can be accessed via smartphones (Lathifah et al., 2021). The ease of access to E-Worksheet via smartphone can make it easier for students to learn (Zahroh & Yuliani, 2021). In addition, students are facilitated in the process of independent learning and communicate with teachers effectively (Ayuni & Tressyalina, 2020). The existence of an E-Worksheet can improve students' cognitive abilities and make the learning process more effective and efficient (Ahmadi et al., 2018; Suryaningsih et al., 2021). However, the existing E-Worksheet does not train students' creative thinking skills (Putri, 2015).

Students' creative thinking skills can be improved through learning Science, Technology, Engineering, Art, and Mathematics (STEAM) (Rahman et al., 2020). STEAM is a learning approach that integrates various disciplines (Irawan, 2022). The STEAM approach comes from developing a STEM approach involving elements of art (Oner et al., 2016). The involvement of art in STEAM learning is essential to bring out students' creative side so that students can think "outside the box" in solving complex problems in the 21st century (Zubaidah, 2019). STEAM

learning can be a means for students to create ideas or ideas based on science and technology through thinking and exploring activities in solving problems based on the integration of science, technology, engineering, art, and mathematics disciplines (Nurhikmayati, 2019). With this integration, STEAM learning will be more connected, focused, meaningful, and relevant for students (Stohlmann et al., 2012). STEAM learning can develop cognitive abilities, foster long-term memory, improve socialization skills, reduce stress, foster learning appeal, and increase student creativity (Sousa & Pilecki, 2013). Another benefit of STEAM learning can be training students' creativity and problem-solving skills to produce a product (Katz-Buonincontro, 2018). Thus, the benefits of STEAM make the STEAM approach suitable for use in this development research as an effort to improve the creative thinking ability of Indonesian students.

The implementation of STEAM learning can be combined with the Project Based Learning (PjBL) learning model so that all STEAM components can be integrated (Priantari et al., 2020; Rahman et al., 2020). PjBL is a learning model whose implementation system is project-based (Refitaniza, 2022). Implementing the PjBL learning model requires students to complete a project through problem presentation, planning, monitoring, assessment, and evaluation (Oktaviani et al., 2022). Several challenges in Project-based learning such as student responsibility, dependency among students, individual accountability, activeness, and social skills (Santos et al., 2023). That PjBL model's challenges can make students more flexible and dynamic in realizing planned project solutions (Arsena et al., 2022). In addition, applying project-based learning models can also increase students' creativity in applying their knowledge in everyday life (Ma'sumah & Mitarlis, 2021). This is in accordance with research conducted by Annisa (2018), which states that students' creative thinking skills increase after applying the project-based learning model to classroom learning. Therefore, the STEAM-PjBL learning model suits for project-based learning (Aprilia et al., 2018).

One of the suitable project-based subjects is chemistry (Kamal, 2019). Chemical project experiments involve chemistry to produce real work in the form of innovative products with economic value (Astuti, 2015). Creative products resulting from project experiments are expected to equip students for entrepreneurship. One of the chemicals that can apply to project experiments is reaction rate. Reaction rate material can be applied in project experiments because the material is applicable (Putri, 2015). The example of the reaction rate project experiment in previous research is like the salted egg-making project with the dry method (Primadi, 2022). That project's experiments only involved science, engineering, and mathematical aspects, but did not involve art and technology aspects. Though the involvement of aspects of art and technology is important for students to develop their creativity and adaptability to technological developments in the IR 4.0 era. Therefore, in this study, researchers tried to develop an experimental model of the reaction rate project that combines aspects of technology, art, science, engineering and mathematics.

The development of the experimental model needs to be packaged in E-Worksheet teaching media so that the project learning process runs smoothly. Thus, the existence of an E-Worksheet is significant for presenting learning steps based on the STEAM project. In addition, the existence of an E-Worksheet is also expected to help students understand the abstract concept of reaction rate material. Because abstract concepts in reaction rate material can make it difficult for students

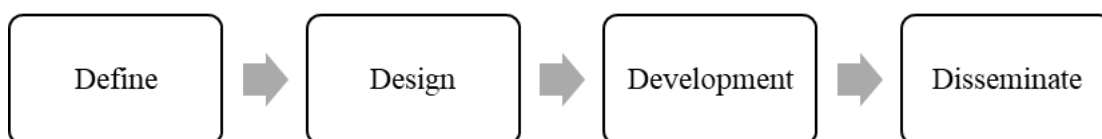
to understand, students usually only memorize theories without understanding the concepts (Herawati, 2013). Research by Marthafera et al. (2018) stated that the average percentage of students' understanding of concepts on the reaction rate material is still relatively low, with a percentage reaching KKM of 40%. The lack of understanding of concepts causes students to have difficulty relating chemical concepts to everyday life (Jansoon et al., 2009). Thus, an E-Worksheet is indispensable to make it easier for students to apply their knowledge to everyday life (Soniya, 2022).

Based on the description above, this study aims to develop STEAM-PjBL-based electronic learner worksheets on reaction rate material and determine the quality of the products produced. The existence of an E-Worksheet is expected to help students understand the reaction rate material and help improve students' creative thinking through STEAM-PjBL project activities. In addition, the E-Worksheet product developed is expected to be useful for teachers as a reference in teaching project-based reaction rate material.

METHOD

This research is an R&D (Research and Development) research. The research model used is 4D which includes the stages of definition, design, development, and dissemination. The flow of this research can be seen in Figure 1.

Figure 1. 4D Development Model



In the define stage, researchers conduct an analysis of needs, availability, concepts, and tasks. Needs and availability analysis was conducted through interviews with three chemistry teachers and several students grade XI. Concept analysis is carried out by analyzing the curriculum, which includes core competencies and basic competencies. Task analysis is carried out by elaborating from concept analysis into several indicators of achievement of competencies and learning objectives.

At the design stage, researchers design learning media products that will be developed through several stages. The first stage is in the form of media selection, namely the selection of learning media in accordance with the needs analysis. The second stage is in the form of format selection, which is the preparation of a media format consisting of the flow of the material presented and student activities. The third stage is in the form of the reference collection, which is the collection of material from several reference sources, such as high school chemistry books, worksheets, and modules. The fourth stage is in the form of the initial design, which is to make a product design that includes material arrangement, image layout, text, video, experimental activities, and media layouting to be loaded in flipbook maker and live worksheet. In addition, the preparation of research instruments is also carried out at this stage.

At the development stage, researchers produce the final form of learning media after going through revisions based on experts and data from field trials (Trianto, 2012). The products developed are adjusted to the results of the needs

analysis. The developed products are then validated and assessed by one material experts, one media experts, and four reviewers and responded by ten students of grade XI high school. The instruments used in the research were product validation sheets, product quality assessment sheets, and student response sheets. Product quality assessment instruments are arranged using the *Likert* scale while student responses use the *Guttman* scale. The compiled research instruments are validated by instrument experts. Then, the product is assessed for quality by one media expert, one material expert, and four teachers as *reviewers*. The data obtained are then analyzed using qualitative and quantitative methods and presented in descriptive form.

Data analysis techniques are carried out by converting the assessment results of media experts, material experts, and *reviewers* in the form of qualitative data into quantitative data based on a Likert scale with Very Good (SB), Good (B), Sufficient (C), Less (K), Very Less (SK) answer options, each of which has a score of 5, 4, 3, 2, and 1. Furthermore, the average score of each aspect and the overall assessment aspect of the score that has been obtained are calculated. The calculation of average score using the following formula:

$$\bar{X} = \frac{\sum x}{n}$$

Keterangan :

\bar{X} = Average score

$\sum x$ = Total score of each rater

n = Number of appraisers

Next, the average score is converted into a qualitative score based on ideal scoring criteria. References to ideal assessment criteria can be seen in Table 1.

Table 1. Ideal Assessment Criteria

Score range	Category
$X_i + 1,8 \text{ SB}_i < \bar{x}$	Very Good
$X_i + 0,6 \text{ SB}_i < \bar{x} \leq X_i + 1,8 \text{ SB}_i$	Good
$X_i - 0,6 \text{ SB}_i < \bar{x} \leq X_i + 0,6 \text{ SB}_i$	Enough
$X_i - 1,8 \text{ SB}_i < \bar{x} \leq X_i - 0,6 \text{ SB}_i$	Less
$\bar{x} \leq X_i - 1,8 \text{ SB}_i$	Very Less

The student response data obtained were converted into quantitative data using the Guttman scale in the form of a score 1 and 0 in positive statements and negative statements. Then calculated as a percentage of product ideality. The calculation of the percentage of ideality is used the following formula:

$$\text{Ideal Percentage} = \frac{\bar{x} \text{ score}}{\text{maximum ideal score}} \times 100\%$$

RESULT AND DISCUSSION

This research aims to develop products in the form of electronic student worksheets containing STEAM-PjBL reaction rate material combined with a flipbook maker and live worksheet. The research stages carried out are as follows:

Define Stage

The define stage includes an analysis of needs, availability, concepts, and tasks. The needs and availability analysis was conducted through interviews with four chemistry teachers from SMA N 5 Yogyakarta, SMA N 3 Surakarta, SMA N 1 Sewon, and MA Mafaza Bantul, and ten students of 11th grade. This interview aims to find out the problems and products needed in schools. Based on the results of interviews with high school chemistry teachers, information was obtained that the implementation of learning on reaction rate material is still limited to using conventional methods such as lectures and reaction rate practicum in the laboratory. Students were also informed that the learning process of reaction rate material only listening to the teacher explain the material contained in the textbook and doing practice questions, thus making students feel bored and bored. Students need active activities in learning so as not to be sleepy, especially in the last class hour. Therefore, an interesting learning model is needed.

Analysis of concepts or materials is carried out through material analysis on the core competencies and basic competencies of reaction rate materials. Next, researchers compiled the concept and sequence of reaction rate material for E-Worksheet. In the task analysis, researchers describe the results of the concept analysis into several indicators of achievement of competencies and learning objectives and compile assignment activities in accordance with learning objectives.

Design Stage

The design phase is prepared based on the needs analysis from the define stage. Based on needs analysis, a learning model is needed that can improve students' critical thinking skills, such as project experiments packaged through interactive learning media. The STEAM-PjBL model is expected to improve students' creative thinking skills and learning interests. The learning media chosen to package the learning model used is the electronic student worksheet (E-Worksheet). E-Worksheet has several advantages, such as ease of access and practicality, supports the smooth learning process, and attract students' learning interests. The next activity is the preparation of the E-Worksheet media format, including cover, foreword, table of contents, instructions for using the E-Worksheet, basic competencies, learning objectives, material summary, student activities/exercises, bibliography, appendices, and discussion. The E-Worksheet design was created using Canva and then combined with a flipbook using flip builder software. Student activities compiled in Canva are also inputted into the live worksheet platform so that students can work on E-Worksheet online.

The initial stage in making E-Worksheet is to create various forms of design elements, including coloring, header footers, and layouts in Canva. Then, enter a summary of the material, drawings, and calculation formulas. Video sample questions are uploaded on youtube and linked in E-Worksheet through images linked to the video link. Furthermore, upload student activities into the live worksheet platform so that students can work on E-Worksheet online by clicking the image connected to the live worksheet link. After all the E-Worksheet components are compiled, next download the E-Worksheet file from Canva in .pdf format and convert it into flip builder software. The design of the conversion results can be seen in Figure 1.

Figure 1. Display of E-Worksheet Flipbook



The final product of the E-Worksheet has an integration of the STEAM-PjBL model in reaction rate material, which consists of fundamental questions, preparation of project schedules, project design, supervision of project progress, analysis of results analysis, and project evaluation. The integration is in accordance with research (Refitaniza & Effendi, 2020) that e-worksheet with STEAM-PjBL-based consists of containing assignments, work steps, analysis of assessment and evaluation results. The integration is expected to improve students' creative thinking skills, such as fluency, originality, flexibility, and elaboration. This is in accordance with the research of Khamhaengpol et al., (2021) that STEAM project activities help students to find creative solutions to problems

The basic question contains questions about how to maintain the resistance of raw materials such as fruits and vegetables so that they do not rot quickly. The fundamental questions are adjusted to the basic competencies on the reaction rate material in the 2013 curriculum. Fundamental questions can improve students' creative thinking skills, such as originality, fluency, and flexibility. Increasing the ability of originality in terms of originating unique or original ideas in finding problem solutions, fluency in providing various solutions, and flexibility in generating ideas from various points of view to maintain the resilience of raw materials. The following basic questions on the STEAM-PjBL project can be seen in Figure 2.

Figure 2. Basic Questions



The implementation of project activities is carried out for 2-3 days, which begins with a discussion on the preparation of project schedules between teachers and students so that the implementation of the project runs in a structured manner. The project activities carried out are in the form of making mini coolboxes. The project schedule view can be seen in Figure 3.

Figure 3. Project Schedule



The image shows a project schedule table titled 'JADWAL PROYEK' (Project Schedule) on a yellow background with a black binder clip at the top. The table has four columns: No, Hari/Tanggal, Hari ke, and Kegiatan. It lists three activities over three days.

No	Hari/Tanggal	Hari ke	Kegiatan
1		pertama	Mengiapkan alat dan bahan
2		kedua	Merangkai Cooler system
3		ketiga	Membuat mini coolbox dan menghubungkannya ke listrik

At the project design stage, aspects of creative thinking skills are developed in the form of fluency, originality, and flexibility in determining various ideas based on several sources to create creative projects and elaboration in making mini coolboxes. The project design contains the tools and materials needed in the creation of the Coolbox mini project. The project design display can be seen in Figure 4.

Figure 4. Project Design



The working steps for making a mini coolbox consist of 3 parts, namely assembling the Peltier cooler system, making a mini coolbox, and connecting electricity to the mini coolbox. When assembling the Peltier cooling system involves STEAM elements in the form of technology and engineering. The technological element is found in the Peltier cooling technology as the main coolant and the engineering element in assembling the Peltier cooling system. The working steps of assembling the Peltier cooling system can be seen in Figure 5.

Figure 5. Steps to assemble the system cooler peltier



The results analysis and discussion sheet contain several questions about the results of the Coolbox mini project. The questions of result analysis involve STEAM aspects in the form of aspects of science, technology, engineering, and mathematics. The aspects of science is contained in the question of the reaction rate factor used in making the mini coolbox, the aspects of technology and engineering in the question of the working system of the Peltier cooler in the mini coolbox project, and the aspect of mathematics in the lowest temperature measurement achieved by the mini coolbox project.

The technological aspects of mini coolbox product is contained in the research of Shi et al., (2023) that the cold temperature produced by the peltier module comes from the heat absorption flow on one side of the peltier and the heat release flow on the hot side of the peltier. In addition, the scientific aspects of mini coolbox product is also found in the research of Lawal & Chang, (2021) which applies a low temperature reaction rate factor to maintain food security.

Figure 9. Analysis and Discussion Sheet

The worksheet is titled "Analisa Hasil dan Pembahasan" (Analysis of Results and Discussion). It contains two questions and corresponding answer boxes:

1. Bagaimana sistem kerja pendingin peltier pada mini coolbox tersebut? Dan berapa suhu terendah yang berhasil dicapai proyek mini coolbox tersebut?
Jawab : _____
2. Jelaskan faktor apa saja yang diterapkan mini coolbox tersebut untuk menyimpan makanan buah/sayur?
Jawab : _____

Project evaluation is prepared based on the project implementation process. Students are asked to evaluate the obstacles experienced during the project process. This evaluation is expected to be a matter of consideration and improvement for students and teachers. Here's what the project evaluation sheet looks like, which can be seen in Figure 10.

Figure 10. Project evaluation sheet

The worksheet is titled "Evaluasi Proyek" (Project Evaluation). It contains a question:

Apa saja kesulitan yang Anda temukan selama pelaksanaan proyek?

Development Stage

The developed E-Worksheet is then validated and assessed for quality. Assessment is carried out using product quality assessment instruments and student responses. Aspects used in product quality assessment include content, language, presentation, graphics, STEAM-PjBL, and creative thinking. While the assessment aspect of student response consists of material presentation, STEAM, ease of use, creative thinking, and PjBL. The assessment was carried out by one media expert, one material expert, four high school chemistry teachers, and 10 Class XI high school students. The results of the assessment of product quality and student response can be seen in Table 3.

Table 3. Results of Product Quality Assessment and Student Response.

Assessment /response	Assessment Aspect	\bar{X} Score	Σ Ideal Maximum Score	Ideal Percentage	Category
Material expert	Material	19	20	93%	Very Good
	Language	20	20		
	STEAM	4	5		
	PjBL	4	5		
	Creative Thinking	4	5		
Media expert	Serving	14	15	97%	Very Good
	Graphic	20	20		
Reviewer	Material	17,5	20	90%	Very Good
	Language	18,5	20		
	Serving	13	15		
	Graphic	18,75	20		
	STEAM	4,5	5		
	PjBL	4,5	5		
	Creative Thinking	4,5	5		
Student	Material	1,9	2	93%	Very Good
	STEAM	1,7	2		
	User Friendly	1,9	2		
	Creative Thinking	1,9	2		
	PjBL	1,9	2		

Based on Table 3, the quality of the E-worksheet based on STEAM-PjBL in reaction rate material gets a very good category with a percentage of ideality by material experts of 93%, media experts of 97%, and reviewers of 90%. The results of the quality assessment showed that the E-Worksheet developed has an interesting presentation, the language used is communicative and can increase student motivation and understanding of the reaction rate material. The serving and graphic media aspect have very good result so it can attract students for learning chemistry. This is accordance with research (Ayva, 2012) that the use of worksheets improves students' understanding and analysis of science. E-Worksheet can be used anywhere and anytime so that students can learn independently. In addition, there is an user friendly aspect of flipbook e-worksheets such as navigation features and images connected to video links, making it easier for students to access learning videos. The existence of

projects using the STEAM-PjBL method can improve students' creative thinking skills in facing challenges in everyday life (Pratiwi et al., 2019).

The next stage, the E-Worksheet developed, was responded to by ten high school students in 11th grade. Based on the results of student responses, the quality of the E-Worksheet developed received an ideal percentage of 93% with a very good category. The results of student responses show that E-worksheet, which was developed with the STEAM-PjBL project, can increase students' enthusiasm for learning and creative thinking. These results show that E-Worksheet can improve creative thinking skills. The results of this study are in accordance with Herlina's (2021) research which states that E-Worksheet based on PjBL can improve students' creative thinking skills.

The results showed that the STEAM-PjBL-based e-worksheet media developed was able to improve students' creative thinking skills. The results of this study received a positive response from students that students felt happy learning chemistry using the developed e-worksheet media. Because the material presented is coherent, easy to understand, as well as has various illustrations, images, and videos that can attract students' learning interest. E-worksheets presented in the form of flipbooks are considered in accordance with today's developments where students can learn to use mobile phones anywhere and anytime, so students do not have to bother carrying books to understand the material. The results of this study also received a positive response from teachers that teachers are interested in implementing the STEAM project as a learning model in the classroom. This is because the STEAM project in the reaction rate material is considered relevant to the independent curriculum which is a development of the 2013 curriculum. The creative thinking skills developed through the STEAM project are flexibility, originality, elaborate, and fluency. These capabilities can be improved through the process of discussion answering fundamental questions, project design, elaboration of project work and analysis of project results.

The results of this study are in line with the research of Pan et al. (2023) that in the applied experimental group, project learning resulted in creative thinking skills and high learning motivation. The application of the STEAM project learning model is in accordance with the results of Gomez-del Rio & Rodriguez's research, (2022) that project learning is able to help students to integrate various knowledge and improve student skills. In addition, the results of this study are also in accordance with Beneroso & Robinson's research, (2022) that online packaged project learning is considered more effective in developing engineering design skills. The STEAM project implemented is in accordance with the research of Ju et al., (2022) that the application of STEAM can develop students' creative and critical thinking. In another study by (Albar & Southcott, 2021) that investigative activities in project-based learning can significantly improve students' creative thinking skills, which is in accordance with the results of this study in fundamental questions and result analysis sheets. The project learning model packaged in an electronic worksheet is in accordance with the research of Zen et al., (2022) that project learning through online media can improve students' entrepreneurial abilities through experience gained during project learning. In addition, the results of this study are also in accordance with the research of Malele & Ramaboka, (2020) that students' creativity in designing products is honed through STEAM project activities. The results of this study are also in accordance with the research of Thuneberg et al., (2018) that students' cognitive abilities and creativity increased after using the STEAM module. In addition, according to Perignat & Katz-Buonincontro's research, (2019) that STEAM learning practices demand students' art of

creativity in producing products. Finally, this STEAM project activity is in accordance with Bui et al.'s research, (2023) that the implementation of the STEAM project applies several activities such as asking questions, organize activities/project, process assessment, and product evaluation.

The e-worksheet developed can be an alternative learning medium for students as well as the reaction rate material presented in the e-LKPD can make it easier for students to understand chemical materials. In addition, the STEAM project contained in this e-worksheet can be a reference for chemistry teachers to carry out a project-based chemistry learning process on reaction rate material. The existence of the STEAM project in the e-worksheet is expected to improve students' 21st century skills such as creative and innovative thinking, and collaboration.

This research is limited to reaction rate materials. The material used in the STEAM project is limited to the basic competencies of the 2013 curriculum namely 3.6 and 4.6 where students explain the factors that affect reaction rates using collision theory. and students present information search results on ways of organizing and storing raw materials to prevent uncontrolled physical and chemical changes. For further research, it is recommended to test the effectiveness of the developed E-LKPD on student learning outcomes. In addition, it is expected that research on STEAM-PjBL be extended to other chemicals.

CONCLUSION

This study aims to develop electronic student worksheets of STEAM-PjBL charged reaction rate material to improve students' creative thinking skills. The development model used is a 4D model. Based on the results of the study, the percentage of ideality by media experts, material experts, *reviewers*, and student responses was 97%, 93%, 90%, and 93%, respectively, with very good categories. Therefore, it can be concluded that the resulting E-Worksheet can improve students' creative thinking and is worthy of being used as an alternative learning medium in the learning process. The suggestion for further research, it can be carried out to determine the effectiveness of developed e-worksheet on learning outcome in the classroom. Another that the research on STEAM-PjBL be extended to other chemicals.

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