



## 1. Introduction

The development of the industrial revolution 4.0 has made educational development also increase. One of the things that must be improved is developments in the 21st century. What students need to support the 21st century are science process skills and critical thinking skills (Choudhary et al., 2021). The ability to adapt to the challenges of the 21st century is crucial through the development of student skills, including initiative thinking, cooperation, working in a group, peer training, reasoning, problem-solving, obtaining and using information, planning, leaning skill, affective skill, and multicultural skill (Nurtamara et al., 2019).

Science process skills are really needed by students because science process skills make students active and involved in finding information so that students can apply the information they get. Apart from scientific process skills that support the 21st century are critical thinking skills (Nurtamara et al., 2019).

(Fairuz et al., 2019) explained that electronic worksheet is a computer-assisted media equipped with pictures, animations and videos so that students do not get bored. (Mohd Zahid & Ahmad, 2021) argue that profit using e-worksheet is : 1) saving space and time , 2) possible user for marking things important without worry damaged by graffiti , 3) friendly environment because no there is paper , ink , etc. used , 4) font big and small easy changed , 5) always available because digital, 6) size and capacity small so that can accommodate lots of e-worksheet, 7) economical cost.

The low science process skills one of the students caused using worksheet that has not been used supports the learning process. Statement the reinforced by (Wisdiarman et al., 2020) who stated that the worksheet is used in schools not yet prepare science process abilities student because only load several worked questions student. According to (Sari et al., 2020) also stated that the worksheet is used no load activities that include student for more develop science process abilities.

One solution that can be done to improve science process skills is through p learning a bad 21. Learning The 21st century is learning that integrates literacy abilities, knowledge skills, skills and attitudes, as well as mastery of technology. Competencies that must be possessed in the 21st century are: critical thinking skills, creativity skills, communication skills and collaboration skills.

According to (Rustan et al., 2020) stated that the use of worksheet can improve students' science process skills because it contains guides for students to carry out several activities regarding science process skills so that students gain new knowledge and skills to master. The worksheet can be based on Problem Based Learning (Sartika et al., 2020). According to (Saleh et al., 2020) problem based learning is a learning process based on problems that ask students to solve them scientifically.

In order to teach simple airplane material to improve students' science process skills and critical thinking skills, problem based learning-based worksheet is needed. The development of e- worksheet based on problem based learning is needed because until now worksheet based on problem based learning is still in printed form, where printed worksheet is not yet able to facilitate learning in the 21st century, so it requires electronic worksheet or e-worksheet (Santoso et al., 2020).

Based on the results of observations at SMP Negeri 4 Tanantovea, it was still found that students' science processes had never been measured, and learning did not involve science processes in the classroom. Meanwhile, students' critical thinking skills were found to be problematic, namely teachers were not used to giving questions mixed with hots (high level thinking), most of the questions given were only taken from the internet, not made by themselves, so they only fell into the C1 to C3 range, while critical thinking skills were in the C4 to C6 range.

One solution that can be done to this problem is to develop an e-worksheet with distinctive characteristics using an integrated skills PBL model 21st century to improve students' science process skills and critical thinking skills. Objective study this that is for produce e-worksheet characteristics of the integrated PBL model skills effective 21st century for increase science process skills and skills think critical participant educate. The use of E-Worksheets designed with the PBL model will enrich students' learning experiences by allowing them to engage in real-world relevant scientific projects. It goes beyond mere theoretical learning, enabling direct application of scientific concepts in meaningful contexts. Furthermore, the integration of 21st-century skills such as problem-solving, critical thinking, communication, and teamwork will prepare students to become lifelong learners ready to tackle complex challenges in the real world. They will learn how to effectively use technology to access, evaluate, and present information, in line

with the demands of the digital age. Additionally, this approach promotes self-directed learning and the development of metacognitive skills. Students will not only master scientific content but also learn how to understand and manage their own learning processes more effectively.

## 2. Research Methods

Type study This is study development (*Research and Development*), with the ADDIE development model. Population and sample study is all over participant educate class VIII A at SMPN 4 Tanantovea. Research data collection techniques done with using the e-worksheet feasibility test through charging questionnaire by participants educate, test choice double for measure science process skills and tests essays for measure skills think given criticism each as much twice, that is before learning (*pretest*) and after learning (*posttest*). Results data study analyzed in a way descriptive with application statistics.

## 3. Results and Discussion

This research was conducted to develop e-worksheet in physics learning based on *problem-based learning* (PBL) with a 21st century skills approach on simple airplane material. This research and development use a model procedure developed by Sugyono, namely ADDIE which includes: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation The results of research and development from each stage, namely:

Validation of the instruments used in this research consisted of a learning implementation plan (RPP), a science process skills test, a critical thinking skills test, and a student response questionnaire. The following table displays the results of the validation of the instruments used in the study:

Instrument	Validat or 1	Validat or 2	Keterang an
Lesson Implementation Plan (RPP)	3.87	3.47	Valid
Science Process Skills Test	3.80	3.90	Valid
Student Response Questionnaire	3.20	3.00	Valid

Based on the results of the RPP validation on validator I, an average value of 3.87 was obtained in the valid category and validator 2 obtained a value of 3.47 in the valid category. Validation of the science process skills test on validator 1 obtained an average score of 3.80, and validator 2 was 3.90 in the valid category. Validation of the critical thinking skills test on validator 1 obtained an average score of 3.60, and validator 2 was 3.00 in the valid category. Validation of student response questionnaires on validator 1 obtained an average score of 3.20, and validator 2 was 3.00 in the valid category. In this study, the validation of the instruments used was a crucial step to ensure the reliability and validity of the data collected. According to the validation results, the Lesson Implementation Plan (RPP) received an average score of 3.87 from Validator 1 and 3.47 from Validator 2, both falling within the valid category. This indicates that the RPP used was well-accepted and suitable for use in the research context. Similarly, the Science Process Skills Test underwent positive validation processes, with Validator 1 giving an average score of 3.80 and Validator 2 giving 3.90, both falling within the valid category. This confirms the test's reliability in effectively measuring students' science process skills. While information on the validation of the Critical Thinking Skills Test was not provided, the validation of the Student Response Questionnaire showed an average score of 3.20 from Validator 1 and 3.00 from Validator 2, both in the valid category. This indicates that the questionnaire effectively gathers students' responses regarding their learning experiences. Overall, these validation results reinforce confidence in the reliability of the instruments used in this study, ensuring that the data collected provide an accurate picture of the effectiveness of implementation and the learning outcomes achieved by the students.

**Analysis Stage.** E-worksheet development process begins with the analysis stage which consists of needs analysis, material analysis and student characteristics analysis.

The needs analysis was obtained from the results of interviews with teachers and students, and it was found that in the learning process in the classroom they had never used electronic teaching materials, such as e-worksheet. The learning process only relies on printed books/packages, so learning is less than optimal. Apart from that, teachers also need supporting teaching materials to help achieve the learning process. In the learning process, teachers rarely use problem-based learning models. Generally,

teachers only use the Inquiry learning model and the cooperative learning model. The use of a 21st century skills approach has also never been implemented.

Analysis of student characteristics was obtained from the results of direct classroom observations. The results of the analysis of student characteristics were obtained, namely the lack of interest in learning by students, students tended to be lazy about opening textbooks before the learning process began, there were several students who did not bring textbooks because they were too thick and heavy, there were several students who rarely work on the questions given by the teacher, are less active in the learning process (tend to be quiet), there are still some students who get grades below the KKM.

Material analysis is carried out by observing the curriculum and syllabus used, so that the learning activities used in e-worksheet are in accordance with the objectives of achieving the subject. From the results of material analysis, it was found that in class VIII there are two basic competencies (KD) which enable the development of worksheet with characteristics using an integrated PBL model of 21st century skills. These basic competencies are KD 3.5 " Describe the use of simple machines in everyday life and their relationship to muscle work in the human skeletal structure " and KD 4.5 " Conduct an investigation into the mechanical advantages of simple machines ".

**Design Stage.** At this stage the researcher began to compile the e- worksheet, which was divided into 3 parts, namely the initial part of the worksheet, the core/content of the worksheet, and the final part of the worksheet. The initial part of the worksheet created by the researcher consists of the front page (cover), learning objectives, problem formulation, and instructions for using the e-worksheet. Furthermore, the core part of the worksheet contains material contained in chapters and sub-chapters on simple aircraft material. At the stage of preparing the main part of the worksheet, 3 stages of analysis are carried out, namely task analysis, content, and analysis of assessment standards in the worksheet. After the core part of the worksheet has been created then enter the final part of the worksheet. The final part of the worksheet contains conclusions from the learning results obtained.

**Development Stage.** At this stage the worksheet has been designed using PBL steps integrated with 21st century skills on simple aircraft materials and instruments to measure the

performance of the worksheet. E- worksheet validation in this research was carried out by 2 expert validators. Based on the validation results by validator 1, an average value of 3.70 was obtained in the valid category and validator 2 was 3.00 in the valid category. The average value was obtained from 4 aspects of assessment, namely: presentation, language, content and design of the e-worksheet. Products that have been validated are ready to be tested on students.

**Implementation Stage.** E-worksheet development product is characterized by using an integrated PBL model of science process skills and critical thinking skills that has been validated by experts, then enters the implementation stage of the e-worksheet product which is tested on groups of students. Students carry out learning activities from the product being developed, then undergo a series of tests to test the product's effectiveness. The findings of the study revealed that the student worksheets developed through the STEM approach were deemed appropriate for use in learning and were able to effectively enhance students' critical thinking skills (Hartini et al., 2020).

**Practicality of e-worksheet.** The practicality of e-worksheet can be seen from the product implementation observation sheet. The observation sheet was assessed by the observer, the results of the assessment analysis from the observer showed that the average assessment of each aspect was categorized as very practical with a score of 83%. Overall, it shows that the e-worksheet developed is very practical for use in learning. The product implementation observation sheet contains three aspects, namely product appearance aspects, implementation aspects and e-worksheet effect aspects. Effectiveness of e-worksheet on science process skills

The effectiveness of e-worksheet is measured in tests of students' science process skills through effect size analysis Cohen's d from the pretest and posttest results. The effectiveness test was carried out to determine the effectiveness of using the product on students' science process skills on simple aircraft material. The effectiveness data can be seen in table 2 below:

Table 2. Effectiveness of e-worksheet on science process skills

Pretest Average Score	Posttest Average Score	Effect Size (Cohen's d)
44.2	79.9	2.61 (Very Large Effect)

The average pretest score obtained by students was 44.2 and the average posttest score was 79.9. This shows that the posttest score is higher than the pretest score. Increasing students' science process skills is determined through calculating the effect size  $d$  Cohen's. Based on this test, a value of 2.61 was obtained or it had a very large effect. To confirm the average difference between the pretest and posttest, graph image is presented below.

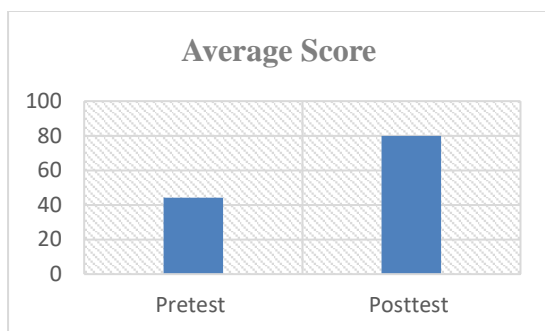


Image 1. Comparison chart of pretest and posttest

Table 2 and Figure 1 significantly demonstrate the impact of the intervention on improving students' pretest and posttest scores as well as Cohen's  $d$  effect size values in the context of the study. The average score of the pretest which reached 44.2 and increased significantly to 79.9 in the posttest confirms the effectiveness of the method used in improving students' science process skills. In addition, the Cohen's  $d$  value of 2.61 indicates that the intervention had a very large effect, indicating a significant change not only statistically but also practically in students' learning outcomes. As an illustration, the study by (Yang & Ogata, 2023). Also shows that large Cohen's  $d$  effect size values such as this are consistently associated with marked improvements in student learning across a range of educational contexts. Thus, this table not only provides concrete evidence of the effectiveness of the intervention in improving students' science process skills, but also corroborates the research findings with strong empirical support.

The effectiveness of e-worksheet is also measured in tests of students' critical thinking skills through effect size analysis Cohen's  $d$  from the pretest and posttest results. The average pretest score obtained by students is 27.5 and the average posttest score obtained by students is 79. This shows that the posttest score is higher than the pretest score. Based on the effect size test Cohen's  $d$  value was 5.84 or had a very large effect. Evaluation Stage

The final stage of developing this worksheet is to carry out an evaluation to see the feasibility of an e-worksheet characterized by using an integrated PBL model of 21st century skills for students. Evaluation is carried out formatively and summatively. Formative evaluation is carried out at each stage. Formative evaluation at the analysis stage such as needs analysis, analysis of student characteristics, and material analysis to adapt to the appearance of the e-worksheet product later. Evaluation at the design stage is by adapting the product to be developed with a problem-based learning model that is integrated with 21st century skills. Evaluation at the development stage is by making improvements based on suggestions given by the validator.

Evaluation at the implementation stage is carried out when looking at the difficulties experienced by students in limited trials. After each development stage is completed, a E-worksheet created can help students in learning, especially in achieving learning goals. The existence of e-worksheet for science learning using a problem-based learning model that integrates 21st century skills is expected to provide new insights to students regarding science process skills and students' critical thinking.

In relation to 21st century skills, namely 4C, through the problem-based learning model it can develop critical thinking skills. This model can equip students with 21st century skills including science process skills (Suryaningtyas et al., 2020). The learning process using PBL model e-worksheet can involve students individually and in groups in problem solving activities which has been designed by the teacher (Sujatmika et al., 2019). In this way, students can develop their skills through the process of asking, analyzing, synthesizing, interpreting, reasoning, and the ability to conclude (Adhelacahya et al., 2023).

PBL based e-worksheet is designed to integrate 21st century skills to help students think and reason, so that through e-worksheet it can make it easier for students to carry out learning activities independently and practice honing their skills (Azizah & Kuswanti, 2022). The integration of 21st century skills aims to further maximize the implementation of the *problem based learning model* as a model contained in the e-worksheet to improve science process and critical thinking skills.

#### 4. Conclusions and Suggestions

Based on the results of the research and discussions that have been carried out, the conclusion of the study is, namely: E-worksheet

characterized by using the integrated PBL model of 21st century skills developed as having a feasibility percentage of 93% in the very good category. E-worksheet is characterized by using an integrated PBL model of 21st century skills which was developed to be effectively used to improve students' science process skills as seen from the *effect size value* obtained, namely 2.61 with the interpretation of having a very large effect. E-worksheet is characterized by using an integrated PBL model of 21st century skills which was developed to be effectively used to improve students' critical thinking skills as seen from the *effect size value* obtained, namely 5.84 with the interpretation of having a very large effect.

The suggestions from the research, Implement PBL-integrated E-Worksheets to foster interactive learning and contextual problem-solving aligned with curriculum standards. Integrate critical 21st-century skills like critical thinking, collaboration, communication, and creativity to prepare students effectively for future challenges. Enhance technology integration in E-Worksheets to improve accessibility and engagement. Focus on developing students' metacognitive skills such as self-reflection and learning strategy management. Establish regular evaluation and continuous improvement processes for PBL-integrated E-Worksheets to optimize learning outcomes.

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