Development of ASICC-Based Modern Biotechnology Student Worksheets to Improve Students' Critical Thinking Skills

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Abstract. This research aims to develop modern biotechnology worksheets to improve high school students' critical thinking skills. This research uses design research with a development study which consisting of preliminary studies and prototyping. The research was conducted to senior high school in Kediri, East Java. Critical thinking skills scores are taken using a rubric that is integrated with essay test questions. Data was collected using pre-test and post-test questions, then analyzed quantitatively and descriptively. The results of this research reveal that ASICC-based student worksheets can improve the critical thinking skills of students in the medium category. Student learning stages in the form of searching, interpreting, and creating in the ASICC learning model can improve students' critical thinking skills.

Keywords: Modern Biotechnology, Critical Thinking Skills, Student Worksheets, ASICC

1 Introduction

In the development of the 21st century, one of the goals of education is to encourage students to be able to master the skills contained in 21st century skills [24]. The 21st century skills in question include (1) critical thinking and problem solving; (2) collaboration; (3) good communication; (4) creative and innovative thinking skills; (5) social responsibility; and (6) work ethics [26].

One of the skills that students need to continue to improve is critical thinking. According to Hasanah et al. [14], this condition is because students' thinking skills in Indonesia are still at a low level. Critical thinking skills are considered important for students because they can respond to or connect concepts and material, so they are able to understand and solve problems in class [5; 22]. Students can develop ideas for thinking about problems, one of which is learning [8]. Improving critical thinking skills requires

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variations during the teaching and learning process, one of which is using learning media that can improve critical thinking skills [9].

Based on research results, students at SMA Negeri 1 Kediri have low critical thinking skills. It can be seen from the analysis when answering students' questions that their answer descriptions are correct and clear, but the reasons and arguments given are still unclear. This is an indicator of their weak critical thinking skills, based on the Zubaidah rubric matrix. In previous research [14], critical thinking skills were low because the learning process only focused on the material by memorising concepts, so students were not given the opportunity to analyse a problem, identify, conclude, or come up with new ideas or act on a problem. This has an impact on low critical thinking skills because the discussion process regarding problem solving still looks passive. Research [17] explains that SMA Negeri 1 Kediri also still uses media that is not yet interactive, so it does not hone students' critical thinking skills. One of these causes is the lack of student interest in learning media, and this will have an impact on the lack of sharpening of students' critical thinking skills [9; 21].

Student worksheets are learning media that can be applied in schools and used as a learning instrument based on critical thinking skills [13]. However, not all student worksheets in circulation can develop thinking skills. Many of the student worksheets in circulation are general in nature and only contain a summary of the material [9] so they do not train students to think critically and be independent [2]. Therefore, it is necessary to design student worksheets according to the background conditions and situations faced in learning activities [7].

Student worksheets are designed to include modern biotechnology material. This is due to the abstract nature of modern biotechnology material, so learning media are needed that can help students understand concepts. Based on research [33], it is proven that the high level of difficulty experienced by students in modern biotechnology material is partly due to its abstract nature. For example, students have difficulty imagining the cloning process in animals, and there is still little understanding of concepts regarding recombinant materials and the impact of modern biotechnology or plant tissue isolation methods.

Based on the description and problems above, the solution that will be implemented is to implement student worksheets based on ASICC. Some previous research that is still related is the development of ASICC-based student worksheets, which have been proven to be able to maintain high-level thinking skills, especially critical thinking, and increase collaboration [22]. The ASICC learning model consists of adapting, searching, interpreting, creating, and communicating. At the ASICC stage, students will be guided to practise critical thinking skills, achieve learning objectives, collect key information, solve contextual problems, share ideas, and produce certain products. Critical thinking skills cannot appear suddenly, so they need to be habituated, programmed, structured, and organised [22; 6; 10]. In research [29; 21; 30; 25], it was also explained that student worksheets designed using the ASICC strategy influenced improving students' metacognition skills and collaboration skills. Research relevant to the ASICC learning strategy later revealed that learning designs in biology subjects that implemented the ASICC learning strategy were successful in helping students understand concepts, so that stu-

dent learning outcomes improved [1; 10; 18; 19; 20; 28]. Therefore, the aim of developing ASICC-based student worksheets on modern biotechnology material is expected to improve high school students' critical thinking skills to achieve 21st century skills.

2 Method

This research was carried out at SMA Negeri 1, Kediri, East Java. The research was carried out for six months in the even semester 2022-2023, starting from February to July 2023. The subjects of this research were 20 students in classes X–9. This research uses development research, with a development research type consisting of a preliminary study and prototyping using a formative evaluation flow. The following is a research and development flow diagram according to Tessmer [27] in Fig. 1.

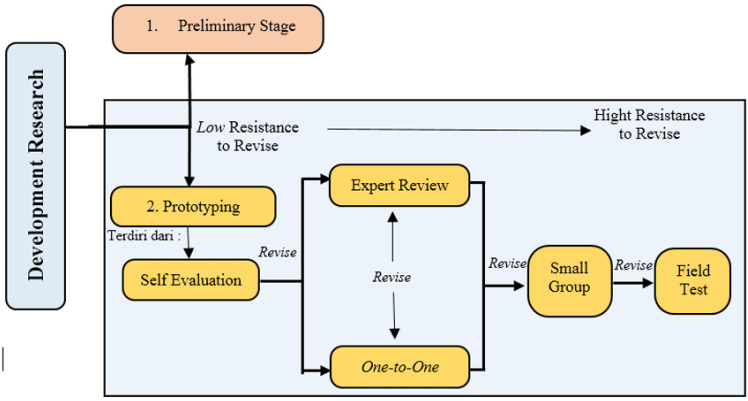

Fig. 1. The development research stage uses a formative evaluation flow, adapted from Tessmer.

Data on critical thinking skills was collected using essay tests that were applied be fore and after learning took place by applying ASICC-based biotechnology student worksheets, then analysed quantitatively and descriptively. The scores used to measure critical thinking skills are taken using the critical thinking skills assessment rubric in tegrated with essay questions from [32], which can be seen in Table 1.

Table 1. Rubik for assessing critical thinking skills integrated essay test from Zubai dah.

Score	Criteria of Assessment
Score 5	• All concepts are correct, clear, and specific. • All answer descriptions are correct, clear, and specific, supported by strong, correct reasons and clear arguments. • good flow of thinking; all concepts are interconnected and integrated. • Grammar is good and correct. • All aspects are visible, and the evidence is good and balanced

Score	Criteria of Assessment
Score 4	• Most of the concepts are correct and clear but lacking in specifics. • Most of the answer descriptions are correct and clear, but not specific enough. • good flow of thinking; most concepts are interconnected and integrated. • Grammar is good and correct, there are small errors. • All aspects are visible, but not yet balanced
Score 3	• - Most of the concepts are correct and clear • A small portion of the answer descriptions are correct and clear, but the reasons and arguments are not clear. • The flow of thinking is quite good; a small part is interconnected. • Grammar is quite good, there are spelling errors. • Most aspects appear correct
Score 2	• The concept of lack of focus, exaggeration, or doubt • The Answer description does not support. • The flow of thinking is not good; concepts are not related to each other. • Good grammar, incomplete sentences • A small number of aspects that appear corre
Score 1	• All concepts are incorrect or insufficient. • The reason is not correct. • The flow of thinking is not good. • Grammar is not good. • Overall aspects are insufficient
Score 0	There are no answers or wrong answers

Scores from the pre-test and post-test essay results were then analyzed to determine the level of students' critical thinking abilities using the N-Gain test. The normalized gain (N-Gain) test was carried out to determine the increase in students' higher order thinking skills before and after implementing the ASICC strategy-based biotechnology student worksheet. The following is the formula according to [3]:

$$N-Gain = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximal Score} - \text{Pretest Score}} \times 100$$

Then, the score calculation results are analyzed based on the N-Gain interpretation table according to Hake [11].

3 Results and Discussion

3.1 Results

The following are the stages of developing an ASICC-based modern biotechnology student worksheet:

Preliminary study stage. This stage aims to analyze the main problems that form the background for research into the development of student worksheets. This stage is a preliminary stage consisting of preparation and design stages.

Preparation phase. The preparatory stages are carried out to reveal the characteristics of students, the curriculum applied at school, as well as analysis of the material that will be used in student worksheets.

1. Student analysis

Student analysis was carried out to understand the condition of students who were used as research subjects [4]. Based on the results of the analysis of students at school, the research subjects entered middle adolescence where students were able to think abstractly. These students' conditions require a learning process that challenges their thinking power in solving existing problems [4]. However, the condition of class X-9 students at SMA Negeri 1 Kediri still shows that their activity is weak, and learning is centered on the lecture method. Based on this description, this is because the learning process is still material-oriented, not yet empowering thinking abilities [23].

2. Curriculum analysis

The goal of curriculum analysis is to use the school's curriculum as a research topic. SMA Negeri 1 Kediri carries out learning by implementing the independent learning curriculum. This curriculum is implemented based on following the latest regulations from the Ministry of Education and Culture and the capabilities of the school. In this research, we have entered the even semester, and the independent learning curriculum applies a flow of learning objectives (ATP).

3. Material analysis

Material analysis aims to identify the material or tasks that will be given to students. This research refers to modern biotechnology materials. Biology learning outcomes include determining the role of biotechnology in preserving biodiversity. The learning objective used is 10.14 to analyse the role of biotechnology in efforts to preserve living things.

Design stage. The design stage is a follow-up to the analysis and design of ASICC-based modern biotechnology student worksheets. The preparation of the student worksheets used consists of student worksheet covers, biology learning outcomes, learning objectives, learning instructions, learning activities based on ASICC (adapting, searching, interpreting, creating, communicating), and reflection.

Prototyping. This stage is carried out in several steps, including:

Self evaluation. This stage is the evaluation stage of the ASICC-based biotechnology student worksheets that have been created. Evaluation is carried out to see the suitability of student worksheets between material (questions according to learning outcomes, biology learning outcomes, and learning objectives), language (in accordance with PUEBI), and media (suitability of the appearance of student worksheets). The results of this evaluation are called prototype 1 and then at the expert review stage.

Expert review. At this stage, prototype 1 is reviewed by experts to obtain a viable product design. The feasibility test in this research was carried out in two stages, namely the feasibility test was carried out with a virtual FGD (Focus Group Discussion) with all expert experts. The experts consist of two lecturers (media experts and material experts) and teacher practitioners. The results of the feasibility test were used to improve the weaknesses of prototype 1.

One-to-one. Prototype 1, which had been improved, was then tested on three students who were not research subjects and who had been determined to have high, medium, and low knowledge abilities. Prototype 1 was distributed to students, and then the researcher explained the learning objectives. During the trial, the researcher also made observations and interviewed the students' worksheets. Based on the results of the analysis, it is known that students still have difficulty answering questions, and there are words from the students' worksheets that are still not understood. The results of this analysis are then used as a reference to improve prototype 1, and these improvements will produce prototype 2.

Small group. At this stage, prototype 2, which had been produced from the previous stage, was then tested on six students other than the research subjects that had been determined. This stage is carried out with the aim of seeing the practicality of the student worksheets that have been created. When conducting the trial, the researcher conveyed and directed the learning objectives to the students, and then the students were grouped into 3 groups. After learning, each group was asked to write comments and suggestions, which were then used by the researcher to revise at the small group stage. The revised results of prototype 2 will produce prototype 3, which will then proceed to the next stage, namely the field test stage.

Field test. After carrying out the practicality test on prototype 2 and obtaining prototype 3, the next stage is the implementation stage in the classroom according to the research subject that has been determined. There were 20 students who followed the stages or worked from the beginning to the end in class X-9 at SMA Negeri 1 Kediri. In this field test learning process, researchers divide it into three stages, which include pretest, field test, and post-test.

4. Pretest

The pretest is carried out before learning begins, so that learning takes place according to the estimated time determined by the researcher. Therefore, when the researcher enters the class, students will immediately do the pretest. The pretest is given to students and consists of five essay questions. The essay test was carried out with the aim of seeing students' thinking abilities before implementing the ASICC based modern biotechnology student worksheet. The answers to the essay test are then assessed using an integrated score from the Zubaidah essay test. Then the score results were tested using N-Gain to determine the level of students' critical thinking abilities.

5. Field test

After the pretest is carried out, it is time to apply the ASICC-based modern biotechnology student worksheet that has been created. At this point, the researcher goes over the learning objectives with the students before they begin any learning activities, making sure they meet the researcher's expectations. In learning activities, ASICC is based on the stages consisting of Adapting, Searching, Interpreting and Creating.

- Adapting, students will be presented with a video with the latest phenomena related to modern biotechnology. This is intended to guide students to self-reflect or orient themselves towards a problem that occurs.
- While searching, students are asked to collect various pieces of information in groups so they can answer questions.
- Interpreting: at this stage, questions will be presented involving students' critical thinking skills. Questions at the interpreting stage are case study questions that occur among students. Students are asked to read, analyse, solve a problem that occurs, and draw conclusions from the various opinions of each member of the team. When analysing, all team members will provide answers from their point of view in finding solutions to problems.
- Creating, students are guided to prepare assignments using the previous material at stages A, S, and I in groups
- Communicating: the results of the creation stage are then presented in front of the class with the group members.

6. Post-test

The post-test is carried out using an essay test like the pretest. At the post-test stage, an essay test was also given to see how the level of critical thinking skills of ethical

students had been applied to the ASICC-based modern biotechnology student worksheet. Answers to the essay test are also assessed using an integrated score from the Zubaidah essay test, as in the pretest. Then the score results were tested using N Gain to determine the level of students' critical thinking abilities.

7. Data analysis

Data on critical thinking skills was obtained from essay tests given at the pretest and posttest stages. The results of the essay test are then calculated using an integrated assessment rubric from the Zubaidah essay test. The scores obtained from pre and post can be seen in Table 2.

Tabel 2. Pretest and posttest essay test scores

	Pretest	Posttest
Total Score	434	481
Average	21.7	24.05
Min	17	23
Max	25	25
Std. Dev	1.945	0.524

Based on the results of the average above, it shows that the average score for the pretest essay test is 21.7 if rounded to a percentage of 86%, while for the posttest essay test, the average score is 24.05 if rounded to 96%. The average score increase reached 10% after implementing the ASICC-based modern biotechnology worksheet. This proves that students' thinking abilities have improved after implementing the ASICC based modern biotechnology student worksheet.

The scores obtained from the pretest and posttest essay tests were then used to find students' N-Gain scores with the aim of determining the increase in students' higher order thinking skills before applying the student worksheets and after applying the student worksheets. The following is the average student achievement from the essay test results contained in Fig. 2

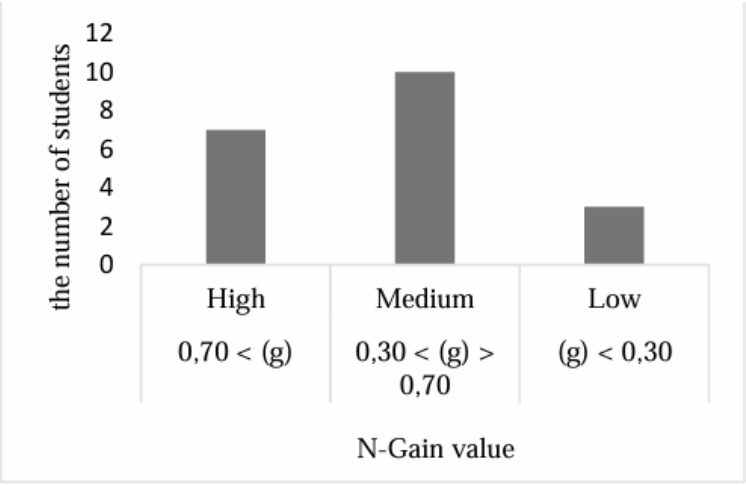

Fig. 2. Average critical thinking abilities of class X-9 students

The essay test's data, as shown in Fig. 2, indicates that the medium category, which included 10 students, had the highest N-Gain score among the students. Meanwhile, there are 7 students who have critical thinking skills in the high category, and 3 students are in the low category. Based on the average N-Gain value of all students, it shows a value of 0.60. Analysis of the average score means that all classes X–9 have critical thinking skills in the medium category. The application of ASICC based modern biotechnology student worksheets shows satisfactory results and has an impact on increasing students' critical thinking skills in class X-9 of SMA Negeri 1 Kediri.

3.2 Discussion

Based on research results, the application of student worksheets during the learning process can improve student learning. This is reinforced by the increase in essay test scores before and after the implementation of the ASICC-based biotechnology student worksheet, reaching 10%. Apart from that, students' critical thinking skills got an average score of 0.60 in the medium category. The average results from the N-Gain test show that the worksheets applied can also maintain students' critical thinking skills.

Increased students' critical thinking skills after implementing ASICC-based student worksheets. This can be seen in several ASICC stages contained in the worksheet. For example, in the adapting stage, students are guided to reflect on themselves or orient themselves towards problems to find out their thinking and analysis abilities for the material to be discussed. This ability makes students learn to analyse in order to develop their' critical thinking skills. At the searching, interpreting, and creating stage, students are trained to collect various information and discuss it with their colleagues to draw conclusions from various opinions and answer the questions presented. The discussion process requires a willingness to dig deeper and consider all information before deciding [16]. This shows an increase in students' critical thinking skills, which can be seen

from students' answers after implementing the ASICC strategy-based student worksheets.

The reason why students' critical thinking abilities increase is also due to their structured learning and self-reflection from the start. This was proven in Santoso's research [21; 22], which revealed that ASICC-based student worksheets were proven to be able to maintain high-level thinking skills, especially critical thinking, and increase collaboration. Critical thinking skills cannot appear suddenly, so they need to be habituated, programmed, structured, and organised [12; 22; 31]. Apart from that, the application of student worksheets designed with structured phases or stages in a learning model can improve students' critical thinking abilities, as seen from students' ability to solve problems, and can build their own concepts in learning [15].

4 Conclusion

Based on research results, the application of student worksheets with student learning stages in the form of search, interpretation and creation in the ASICC learning model can improve students' critical thinking skills. This is proven by an increase in pretest and posttest scores of 10% with an average N-Gain for all students of 0.60.

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