Development of SETS-Based Booklets to Improve Critical Thinking Skills and the Effectiveness of Biotechnology Learning in SMA/MA

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Article Info	Abstract
	Characteristics of learning biotechnology is the existence of a process and product related to everyday life. Therefore, an effective learning process is needed and supported by relevant learning resources. This study aims to analyze the validity of SETS-based biotechnology material booklets used in biotechnology learning. Describe the characteristics of SETS-based biotechnology material booklets. Analyzing students' critical thinking skills in biotechnology learning using SETS-based booklets. Analyzing the effectiveness of biotechnology learning using a SETS-based booklet This research is a Research and Development (R&D) study. The booklet development trial was conducted in 4 schools, with the research subjects being class XII students in each school. Applicative and meaningful learning of biotechnology can be achieved, one of which is by learning using the SETS vision booklet. The SETS vision booklet contains more concise material, accompanied by attractive, colorful pictures that can effectively improve student learning outcomes. The N-gain value obtained is 0.3-0.4 with the medium category and classical completeness reaching 60%. Critical thinking skills that are formed through active learning using SETS vision booklets are 71% -80% in the high category. Critical thinking skills in integrating SETS elements in biotechnology learning can make it easier for students to understand knowledge concepts, so that they can increase learning effectiveness, namely improving learning outcomes and classical mastery.

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INTRODUCTION

Characteristics of learning biotechnology is the existence of a process and a product. This is in line with the basic competition for biotechnology 3.10 based on Permendikbud Number 37 of 2018, where students can analyze the principles of biotechnology and their application as an effort to improve human welfare. Therefore, effective teaching and learning process activities are needed to realize these basic competencies. One suitable approach to support the realization of a more meaningful and effective Biotechnology learning to make students take the initiative in developing knowledge is to take the SETS approach in their learning. The characteristics of learning science with SETS vision in the 2013 Curriculum are the application of integrated science concepts to related technologies, the environment and society. Students are guided to be able to see the positive and negative impacts and solutions from the application of scientific concepts that are integrated with technology, the environment and society (Khasanah, 2015).

The SETS approach in biotechnology learning refers to the SETS learning syntax, namely invitation, exploration, concept introduction, application and evaluation (Suriyanto & Alinata, 2015). At the beginning of learning, students are stimulated to be able to bring up problems or phenomena of everyday life related to biotechnology. Then in the exploration stage, students are asked to find solutions to these problems. After that, the concept introduction stage can help students to see that biotechnology is mutually integrated with elements of technology, the environment, and society. In the application and evaluation stages, students can make inferences about the knowledge they have built themselves in more depth to overcome biotechnology problems that were raised at the invitation stage. Learning biotechnology by referring to the SETS syntax can make it easy for students to build their own biotechnology concepts, so that biotechnology learning can be more effective. This is in accordance with the research of Riwu et al. (2018), that the application of the SETS approach can improve student learning outcomes in biology learning effectively.

Applicative and meaningful learning of biotechnology can not be achieved if the learning only remembers and memorizes the learning material. Students must have critical thinking skills that are formed through active learning by actively interacting with peers, teachers, and also the environment, so that they can create solutions to any problems or phenomena in their lives (Irwan et al., 2019). According to research conducted by Amanda et al. (2018), that the SETS approach in learning can improve critical thinking skills. Critical thinking skills in integrating SETS elements in biotechnology learning can make it easier for students to understand knowledge concepts, so that they can increase learning effectiveness, namely improving learning outcomes and classical mastery.

Based on observations made at four schools, namely SMA N 1 Semarang, SMA Nusa Bakti Semarang, MA Assaadah, and MA Riyadlus Solikhin Al Islamy, biotechnology learning in the classroom still tends to be teacher-centered. The teacher emphasizes more on knowledge material and does not integrate the four elements of Science, Environment, Technology, and Society (SETS), even though the teacher already understands learning theory with the SETS approach. This is because the biotechnology learning resources used do not have SETS vision, so they do not support the implementation of biotechnology learning that integrates SETS elements.

SETS learning must also be supported by SETS-based learning resources as well. Effective, efficient and interesting learning resources are needed to equip students' knowledge. One of the effective and interesting learning resources that can be used in biotechnology learning is booklets. According to Rani et al. (2020), booklets containing relevant materials can be used easily, practically, and effectively to fulfill the basic competencies of learning biotechnology. The SETS vision booklet contains more concise material accompanied by attractive colorful displays, pictures, and illustrations that can effectively improve student learning outcomes (Pralisaputri et al., 2016).

Based on the scope of the problem above, the formulation of the problems discussed in this study are: (1) How is the validity of the SETS-based biotechnology material booklet used in biotechnology learning in SMA/MA. (2) What are the characteristics of SETS-based biotechnology

material booklets developed and used in biotechnology learning in SMA/MA. (3) How are students' critical thinking skills in learning Biotechnology using SETS-based biotechnology material booklets. (4) How is the effectiveness of learning biotechnology using SETS-based biotechnology material booklets. The purpose of this study was to (1) analyze the validity of SETS-based biotechnology material booklets used in biotechnology learning in SMA/MA. (2) Describe the characteristics of SETS-based biotechnology material booklets that were developed and used in biotechnology learning in SMA/MA. (3) Analyzing students' critical thinking skills in biotechnology learning using SETS-based biotechnology material booklets. (4) Analyzing the effectiveness of biotechnology learning using SETS-based biotechnology material booklets in SMA/MA.

METHODS

This research is Research and Development (R&D). The design of this study modifies the development model developed by Thiagarajan et al. (1974), namely the 4-D model consists of four stages of development, namely define, design, develop, and desseminate (Trianto, 2012: 93). This study adopted the 4-D Thiagarajan model until the develop stage. This is because the product is not disseminated. The product is only used as a medium to see the effectiveness of learning and critical thinking skills in the SETS booklet user test group. Booklet used as a source of learning of biotechnology that equipped with LKPD, which makes it easy for students in understanding the material that was delivered by the teacher The stages of research and development that have been carried out in more detail can be seen in Table 1.

Table 1. Research Steps

Kinds of activities	Step I (Define)	Step II (Design)	Step III (Develop)
Sources of Data	Biotechnology teachers and students of class XII	Biotechnology teachers	Validators, teachers and students.
Data Collection Techniques	Interviews and observations	Observations	Questionnaires, tests, observations
Data Collection Instruments	Interview guidelines and observation sheets	Observation sheets	Validation sheets, student response questionnaire sheets, teacher responses and test questions
Data obtained	Basic problems of biotechnology, needs of teachers and students in learning biotechnology	Booklet initial format and design	Expert validation, student response scores to booklets, improvement in learning outcomes, classical mastery, critical thinking skills
Data Analysis	Descriptive	Descriptive	Qualitative descriptive and percentage descriptive

The booklet trial was carried out in biotechnology learning in the classroom to obtain direct input in the form of student responses to the SETS vision booklet that had been produced. The

student's response was in the form of ease of use of the booklet, the material was easy to read and easy to understand. After using the SETS vision booklet, then a test was carried out in the form of working on HOTS questions to measure the effectiveness of learning and critical thinking skills using SETS-based booklets. The research design used One Group Pretest - Posttest Design. The data are in the form of pre-test and post-test scores to measure the increase in learning outcomes using N-gain and the achievement of classical mastery. The test is also to measure the level of critical thinking skills. The booklet development trial was carried out at 4 high schools in the city of Semarang, namely SMA N 1 Semarang, SMA Nusa Bakti Semarang, MA Riyadlus Solihin Al Islamy, and MA Assa'adah. The trial was carried out in 1 class XII in each school.

RESULTS AND DISCUSSION

This RnD research resulted in a SETS-based biotechnology booklet product with very valid, practical and effective characteristics used in biotechnology learning. The SETS-based biotechnology booklet has been validated by materials and media experts. The results of the validation of media experts and material experts can be seen in Table 2 below.

Table 2. Validation of Material Experts and Media Experts

No	Validator	Result	Comment
1	Material Expert	80% (Very	Biotechnology materials have SETS vision and are in accordance with KD
2	Media Expert	90% (Very Valid)	In general it's good It is necessary to add articles from the latest research results and review the relevance of the material to increase students' insight

The SETS-based biotechnology booklet which has been validated by material experts and media experts and has been revised, is then used in biotechnology learning in trial classes at 4 schools. The SETS-based biotechnology booklet that has been used in learning has received student and teacher responses to the booklet. Student and teacher responses to SETS-based biotechnology booklets can be seen in the table below.

Table 3. Student Responses to SETS-Based Biotechnology Booklet

No	Aspect	SMAN 1	SMA Nusa Bakti	MA Riyadlus	MA Assa'adah	Average
1	The SETS vision booklet media design used is attractive	92%	95%	96%	95%	95%
2	Using the SETS vision booklet is very easy	97%	88%	95%	93%	93%
3	Images and illustrations on the SETS vision booklet media support you to better understand biotechnology materials	91%	94%	92%	91%	92%
4	With the SETS vision booklet media can provide motivation to study biotechnology materials	90%	89%	92%	89%	90%

5	The material presented in this SETS vision booklet is related to daily life	95%	88%	89%	91%	91%
6	The material presented in this SETS vision booklet is easy for you to understand	92%	94%	91%	88%	91%
7	Presentation of material in this media helps you to answer the questions	95%	92%	91%	87%	91%
8	The shape, style and size of the letters used are simple and easy to read	96%	94%	96%	93%	95%
	Average	94%	92%	93%	91%	92%

Table 4. Teacher's Response to SETS-Based Biotechnology Booklet

No	Aspect	SMAN 1	SMA Nusa Bakti	MA Riyadlus	MA Assa'adah	Average
1	The SETS vision booklet media design used is attractive	80%	100%	100%	80%	90%
2	Using the SETS vision booklet is very easy	80%	100%	80%	80%	85%
3	Pictures and illustrations on media booklets with SETS vision support teachers to teach biotechnology materials to students	100%	100%	100%	100%	100%
4	With the SETS vision booklet media can provide motivation for teachers in making similar learning media for other materials	100%	80%	80%	80%	85%
5	Submission of material in this SETS vision booklet is related to daily life	80%	80%	80%	80%	80%
6	The material presented in this SETS vision booklet is easy to understand	80%	80%	100%	80%	85%
7	The material presented in this SETS vision booklet is in accordance with KD biotechnology 3.1	100%	100%	100%	100%	100%
8	The shape, model and size of the letters used are simple and easy to read	80%	80%	100%	80%	85%
	Average	88%	90%	93%	85%	89%

Based on the data obtained in the table above, the SETS-based biotechnology booklet developed obtained positive responses from students and teachers. This is because the average percentage score is 60%. Biotechnology materials related to their implications in everyday life using the SETS

approach are then packaged attractively in the form of booklets. The SETS-based biotechnology booklet contains material covering knowledge concepts. This booklet is a learning resource to support learning, so the teacher is not the only source of information (Wulandari et al., 2016). This SETS-based biotechnology booklet was developed as a learning resource used in biotechnology learning which so far has been less effective.

Learning resources are said to be good, if they meet three aspects, including valid, practical and effective (Supriyono, 2009). Validation has been carried out by material experts and media experts and resulted in a valid booklet. The SETS-based biotechnology booklet has been refined based on input from material and media experts, resulting in a SETS-vision biotechnology booklet that is suitable to be used to support the teaching and learning process of biotechnology. This booklet presents biotechnology materials that are integrated with SETS elements. This SETS-based booklet is easy to use, practical, contains relevant, accurate biotechnology material according to the KD biotechnology that is packaged in a concise and interesting way to read and learn because the contents of this booklet are full of pictures and colors. This SETS-based biotechnology booklet has been validated, in addition to containing relevant, accurate and SETS-visioned biotechnology material. This biotechnology booklet also has an attractive media design and color. This SETS-based booklet is also easy to carry or move, so that the presentation of this booklet can develop students' interest in learning. Booklet is an innovative, informative, easy to understand and interesting learning resource, so that it can increase interest in learning and increase learning effectiveness (Pralisaputri, et al 2016).

This SETS-based biotechnology booklet received a positive response from students and teachers. According to the students, this booklet can increase their interest in learning biotechnology, because the booklet which is full of pictures, attractive colors and designs makes students not feel bored quickly in learning. The presentation of colorful and illustrated booklets provides an attractive appearance and is easy to use. Students prefer learning resources with lots of pictures, colors and a few written descriptions (Maghfitothi et al., 2013). The existence of pictures in booklets can increase interest in reading and learning because these pictures can help readers to imagine. Student memory performance can increase because of the help of the created imagination (Suharman, 2005: 99). Students feel that the pictures and illustrations in the SETS-based booklet can help and motivate them to better understand and study biotechnology materials. According to students, the presentation of material in this SETS-based booklet is related to daily life, so it can help students easily understand biotechnology material and answer the questions presented. Learning by linking daily life can increase understanding and motivation to learn (Qamardhani & Surya, 2016).

According to the teacher, the SETS-visioned biotechnology booklet media has an attractive design appearance, making it easier for teachers to use it. Pictures and illustrations on SETS-based booklet media can support teachers to teach biotechnology materials to students effectively. The material in this booklet is in accordance with the KD of biotechnology and is packaged by relating it to everyday life, making it easy to understand. A good learning resource is if the learning resource gets a positive response from students and teachers and is in accordance with the need to support an effective teaching and learning process and can increase learning effectiveness.

SETS-based biotechnology booklet used in biotechnology learning can improve students' critical thinking skills. This is based on the achievement of critical thinking skills indicators after biotechnology learning takes place using the booklet. The critical thinking indicators achieved in biotechnology learning using SETS-based booklets can be seen in Table 5 below.

Table 5. Analysis of Students' Critical Thinking Skills

No	Indicator	SMA N 1		SMA Bakti	Nusa	MA Solikhin	Riyadlus	MA Assa'adah	
		%	Category	%	Category	%	Category	%	Category
1	Can write down what is being asked about clearly and precisely	85%	Very High	72%	High	81%	Very High	69%	High
2	Can write down the relationship of concepts used in solving problems	66%	High	61%	High	61%	High	61%	High
3	Can write problem solving	86%	Very High	75%	High	77%	High	77%	High
4	Can conclude from what is asked logically.	75%	High	60%	Fair	62%	High	62%	High
5	Can provide reasons for the conclusions drawn.	85%	Very High	78%	High	75%	High	78%	High
6	Can review the answers given/written down.	84%	Very High	78%	High	76%	High	77%	High
	Average	80%	High	71%	High	72%	High	71%	High

The SETS-based booklet is also equipped with LKPD which contains analytical questions regarding biotechnology issues. This will stimulate students' critical analytical thinking processes regarding the causes of biotechnology phenomena or issues that can occur and how biotechnology solutions are associated with SETS elements. Learning biotechnology using SETS-based booklets can have a positive influence on students to be actively involved in learning and can train students' critical thinking in finding solutions to problems in everyday life and the surrounding environment (Yörük et al., 2010).

Based on the results of the analysis of students' critical thinking skills after learning using SETS-based biotechnology booklets, it shows that students have achieved the indicators of critical thinking skills. According to Facione (2020), critical thinking indicators are interpretation, analysis, evaluation, inference, explanation and self-regulation. Students' critical thinking skills are shown that students can understand, explain and interpret the data or information that has been given. Students are able to analyze the relationship of the information provided. Students are able to identify the elements needed to make a conclusion. Students can explain the results of their thinking and can regulate their way of thinking.

Student learning outcomes and classical completeness can be seen in Table 6 as follows.

Table 6. Student Learning Outcomes and Classical Completeness

No	Component	SMA N 1		SMA Nusa Bakti		MA Riyadlus		MA Assa'adah	
		Pretest	*Postest*	*Pretest*	*Postest*	*Pretest*	*Postest*	*Pretest*	*Postest*
1	Number of subjects	30	30	24	24	21	21	26	26
2	Highest Score	77	91	77	86	74	86	77	86
3	Lowest Score	60	71	51	57	57	63	49	60
	Average	70	81	65	76	66	77	63	76
	N-gain	0,4		0,3		0,3		0,4	
	Classical completeness	80%		83%		86%		77%	

The posttest results show that the learning outcomes have achieved completeness both individually and classically. This is because the posttest scores obtained have reached the minimum completeness criteria (KKM) that are set, which is >75, so that learning outcomes increase when compared to learning before using SETS-based booklets.

The use of SETS syntax in learning using SETS-based booklets, the knowledge will be remembered longer by students, so that it will improve student learning outcomes. Discussion activities in learning will make students accustomed to actively asking questions, answering questions, and expressing opinions. The existence of discussion activities will help students to be able to develop the concept of knowledge well. Social constructivist learning theory states that if teachers can create adequate social conditions in learning, students can build their understanding and knowledge (Santrock, 2011).

Learning biotechnology using SETS-based booklets can provide students with an understanding that biotechnology has a role in technological progress, the environment and society. This makes the teaching and learning process more interesting, real and applicable. The use of SETS-based biotechnology booklets has a fairly good effect on students better understanding biotechnology materials and improving learning outcomes. This is because the booklets are made according to the needs of students (Ningtyas & Tri, 2014).

CONCLUSION

Based on the results of the research that has been carried out, the following conclusions can be drawn: (1) The validity of the SETS-based biotechnology material booklet used in biotechnology learning in SMA/MA shows very valid results, and gets a positive response by students and teachers. (2) Characteristics of SETS-based biotechnology material booklet which was developed and equipped with LKPD to facilitate students in using it. The booklet contains material that is dominated by pictures and colored charts accompanied by picture explanations, making it practical and easy to use whenever and wherever. (3) Students' critical thinking skills in learning Biotechnology using SETS-based biotechnology material booklets are categorized as high. (4) SETS-based biotechnology booklets are effective in teaching biotechnology in high school. Student learning outcomes in the four schools increased after learning using SETS-based booklets.

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