Natural science modules with SETS approach to improve students' critical thinking ability

A P S Budi¹*, W Sunarno² and Sugiyarto³

¹,² Science Education Department of Post Graduate Programme, Faculty of Teacher Training and Education, Sebelas Maret University, Jl. Ir. Sutami 36A, Surakarta 57126, Indonesia
³Department of Biology, Faculty of Mathematics and Science, Sebelas Maret University, Jl. Ir. Sutami 36A, Surakarta 57126, Indonesia

*Corresponding email: ardiandpugh219@gmail.com

Abstract. SETS (Science, Environment, Technology and Society) approach for learning is important to be developed for middle school, since it can improve students' critical thinking ability. This research aimed to determine feasibility and the effectiveness of Natural Science Module with SETS approach to increase their critical thinking ability. The module development was done by invitation, exploration, explanation, concept fortifying, and assessment. Questionnaire and test performed including pretest and posttest with control group design were used as data collection technique in this research. Two classes were selected randomly as samples and consisted of 32 students in each group. Descriptive data analysis was used to analyze the module feasibility and t-test was used to analyze their critical thinking ability. The results showed that the feasibility of the module development has a very good results based on assessment of the experts, practitioners and peers. Based on the t-test results, there was significant difference between control class and experiment class (0.004), with n-gain score of control and the experiment class respectively 0.270 (low) and 0.470 (medium). It showed that the module was more effective than the textbook. It was able to improve students' critical thinking ability and appropriate to be used in learning process.

1. Introduction
The development of technology will bring various informations, knowledge, and the emergence of various problems. Therefore, it is necessary to manage the knowledge and information, and to solve the problems faced [1]. Several studies have shown that, the ability to use technology and information that involves self-thinking and problem solving independently, greatly helps students in terms of developing their critical thinking competencies [2]. Critical thinking is a method or way of thinking that maximizes results. In this way, students can enjoy their lessons and the teacher can stimulate them to get fun outcomes and analyze information [3].

Critical thinkers are people who are able to analyze and evaluate information, create abstract ideas, opened and directional thinking, and communicate effectively with others [4]. Critical thinking is an effectively needed cognitive skill and intellectual disposition to identify, analyze and evaluate, arguments and truths to discover and overcome personal prejudices and biases and to formulate and provide compelling reasons to support conclusions and make sensible decisions about what must
believe and what to do [5]. Critical thinking skills are important because it enable students to handle social, scientific and practical problems effectively [6].

With this in mind, educators must help students so that they become successful in future world of work to be ready to achieve success in life by focusing education in developing students’ critical thinking skills. With this skill, students are ready to work together successfully, think critically and analytically, communicate effectively and solve problems efficiently. Such activities require students to engage in active learning, engage in high level problem solving skills and to be able to participate in activities. Thus, students will develop strong leadership, communication, teamwork, cross cultural and cross country skills, and most importantly a belief in their ability to contribute in science and engineering field in society [7].

Through critical thinking, students can be taught to critically examine different perspectives on issues regarding the impact of science and technology on everyday life, and to evaluate these issues from a social and environmental perspective. The encouragement of science by educators for students in critical thinking about science and technology will also help to develop their analysis, skills, and abilities to make informed choices in everyday life [8]. Critical thinking as a combination of knowledge, attitudes and performance in each individual that includes ability in understanding skills, identification of hypotheses, conclusions, analysis and evaluation of rational arguments [9].

Science education plays a role in the effort to produce quality learners in accordance with the curriculum and the existing situation. The learning process of science should not only emphasize the understanding of science concepts but must connect with other elements of environmental, technological and community elements incorporated in SETS (Science, Environment, Technology and Society), so that in the learning process students are able to link its four elements in a unity of learning. In the process of learning in middle school, teachers are more likely to provide materials in the form of science concepts only, without linking science with the environment, technology and society. In addition, in the learning process is only oriented in the completion of all learning materials without associating with everyday life. As a result, students lack the ability to view science learning as a whole unit that related to the environment, technology and society [10].

Based on the observation of the researcher, the learning process that occurs in the class does not improve the critical thinking ability and less directly related to daily life. It is characterized by more learning characteristics referring to short-term goals (passing school exams), focusing on procedural capabilities, one-way communication, more dominant routine and low-level questions. Appropriate observations in the learning process and evaluation questions in the learning activities have not been oriented towards the development of students’ critical thinking skills, so students have not been trained in developing their critical thinking yet. Thus, it can lead to low students’ critical thinking ability. Students tend to be difficult to analyze information obtained and tend to accept whether there is any information in the book, students are less active in learning, students tend to be passive in expressing questions or in answering, and not yet able to convey ideas or ideas in solving problems.

This illustrates that students’ critical thinking skills are still low. Science learning should be not just about memorizing material and material understanding, but students need to understand exactly the meaning and value contained in the materials. Through criticizing an event, will train students to think critically also on what is experiencing in Indonesia right now. In addition, critical approach to science teaching can lead to critical dialogue between teachers and students as well as students themselves on the issues they are facing and finding solutions to their solutions. By conducting this critical dialogue, students can discuss and brainstorm what they know about the profound meaning of the science matter [11].

Development of learning is needed to overcome these problems which will be poured in the module that can be used to train critical thinking skills and improve student learning outcomes. The module is a form of teaching material that is packed intact and semantic, containing a set of planned learning experiences designed to help learners understand specific learning objectives. The minimum module contains learning objectives, materials or learning substance and evaluation. The module served as an independent learning tool, so that learners can learn independently at their own pace [12].
The developed module is an natural science module design with the SETS approach. Students are not only invited to think about the use of the concept of science in the form of related technology, but also possible consequences that occur in the learning process of science which being studied into the form of technology to society and its environment. The core goal of SETS education is that this education can make students understand the key elements of SETS and the interrelationship among these elements when studying science. In other words, critical thinking is needed to learn every SETS element [13].

SETS starts from the belief that the relationship between students and the real world must be established. This process will lead the students to recognize the positive problems they have. Environments are created, where students can gather data for their problem solving, consider alternative solutions, determine the best way to solve problems and practice them [14].

The main reason for choosing SETS is because SETS learning is orientated towards students' active participation. Students are more guided to have the ability to think critically on environmental issues, technological developments and the community and also actively seek the problem [15]. The SETS approach is an effective learning approach to improve academic and science achievement [16]. Using the SETS approach can improve students' understanding of the nature of science and attitudes toward science significantly compared to students using traditional learning [17].

Teachers and learners like to have a decisive role in achieving learning goals in SETS learning. The teacher's role creates a thinking pattern that sees the future with its implications, bringing learners to always have integrative thin pattern, invites learners to think critically in facing of something with reference to SETS. Quality learning has a significant influence in producing qualified graduates. To produce a quality learning process, there are many aspects that influence it. These aspects include: qualified teachers and lecturers with qualifications mandated by Teachers and Lecturers from Law field, use of interesting and varied teaching methods, positive learning behavior of learners, and use of appropriate learning media in support the learning process itself [18].

The results of previous research indicated that 95% of students think if the SETS concept is incorporated into the learning process, it provides an opportunity for them to gain knowledge and enhance their understanding among the branches of science, so that hopefully through learning activities that are insightful to each other will get ideas about the results of technology from transformation of science, without destroying or harming the environment and society [19].

2. Method
This type of research is Research and Development (R & D). The development model of this research was Four-D (4-D), which includes define, design, development and disseminate. This research was conducted at State Junior High School 2 Jatisrono. True experimental design method with pre-test and post-test of control group was applied in this research was a research design. The subjects of the study for large-scale trials were students of class VII C as many as 32 students as control class (using BSE package book) and class VII D number of 32 students as experimental class (using IPA module approach SETS), while students of class VII E total 9 students as a limited trial class. The sampling technique which used in this research was simple random sampling.

The instrument of data collection in this research was done by questionnaire and test method. Questionnaires to obtain the data about student's response and the data about teachers' response about effectiveness of modules developed, while the test was used to determine the results of students' critical thinking skills. The tests used in this study were pre-test and post-test in the control and experimental class. The obtained data were analysed descriptively based on the expert validation results, education practitioners and peers as well as the results of questionnaire responses of students and teachers. The test results of critical thinking ability were analysed by calculating the number of relevant to students' answers. Then the test results were tested by the independent sample, t-test to determined whether there are differences before and after treatment was given between the control class and the experimental class. The students' critical thinking skills were also analysed with an n-
gain score to determine the improvement of students' critical thinking skills during the learning process.

3. Result and Discussion

3.1 Research Result
In the module development process, it started with the validation of draft module which consisted on materials, language, and media components by a lecturer who was the expert of teaching materials, a linguist lecturer, a lecturer who was also the expert of media, one educational practitioner and 2 colleagues. The lecturer who was as the expert of material evaluated the content, the linguists checked the language and the picture, the lecturer that was a media expert evaluated the graduation, one practitioner of education (peers review) evaluated the feasibility of presentation in the module. In table 1 below, it can be seen the results of expert validator test which obtained, it showed the average value which was 95.31%. It was concluded that the IPA module with the SETS approach belongs to the very feasible category.

| Validation                                      | N | Score | Average | Max Score | Percentage (%) |
|------------------------------------------------|---|-------|---------|-----------|----------------|
| Material Expert (Content Feasibility)           | 1 | 60    | 60      | 64        | 93.75          |
| Language Expert (Language Eligibility)         | 1 | 40    | 40      | 40        | 100            |
| Media Expert (Feasibility of Graficity)        | 1 | 35    | 35      | 36        | 97.22          |
| Educational Practitioner (Feasibility of Presentation) | 1 | 189   | 189     | 208       | 90.86          |
| Friends (Feasibility of Presentation)          | 2 | 394   | 197     | 208       | 94.71          |
| Average value                                  |   |       |         |           | 95.31          |
| Description                                    |   |       |         |           | Very Decent    |

The limited trial stage which involved 9 students of class VII E State Junior High School 2 Jatisrono to find out the feasibility and effectiveness of natural science module with SETS approach on ecosystem theme. In this limited trial, students worked on the module and then the students' work results were analyzed to determine the feasibility and effectiveness of the module. Student participated in the trial which was limited to a different level, it was intended that the results obtained could represent the entire students in the field who had various capabilities. The results of module-limited trials could be seen from the student's work on the natural science module with SETS Approach in Table 2. The eligibility and effectiveness of the module was measured from the students' achievement in form of their critical thinking skill.

In each of the learning activity involved three students to work on modules on a limited trial. The average of students' critical thinking ability in learning activity obtained the value of 79.16 with good criteria, learning activity II got value 81.94 with good criteria and learning activity III had value 83.33 with good criteria, so that in the average limited trial the overall was 81.47 with good criteria. Thus, it can be concluded that the module feasibility in the limited trial was good or feasible to be used for large-scale trials and students' critical thinking skills increased because of the natural science module with SETS approach and the module used in learning was effective because the level of students' understanding of the module increased with high performance.
Table 2. The Recapitulation of Trial Results Which Was Limited to Students' Critical Thinking Skills

| Learning Activity | Respondents | Fascione's critical thinking indicators | Average | Average per learning Activity |
|------------------|-------------|----------------------------------------|---------|-------------------------------|
|                  |             | Interpretation (%) | Analysis (%) | Explanation (%) | Evaluation (%) | Inference (%) | Self regulation (%) |                  |
| I                | Student A   | 75 | 50 | 75 | 75 | 50 | 75 | 66.67 | 79.16                  |
|                  | Student B   | 75 | 75 | 75 | 100 | 100 | 75 | 83.33 | 79.16                  |
|                  | Student C   | 75 | 100 | 100 | 75 | 75 | 75 | 87.50 | 81.94                  |
|                  | Student D   | 75 | 75 | 75 | 100 | 75 | 75 | 79.17 | 83.33                  |
| II               | Student E   | 100 | 75 | 100 | 100 | 75 | 75 | 87.50 | 81.94                  |
|                  | Student F   | 75 | 100 | 50 | 75 | 75 | 100 | 79.17 | 83.33                  |
|                  | Student G   | 75 | 75 | 75 | 100 | 75 | 75 | 79.17 | 83.33                  |
| III              | Student H   | 100 | 75 | 100 | 100 | 75 | 100 | 91.67 | 83.33                  |
|                  | Student I   | 75 | 75 | 75 | 100 | 75 | 75 | 79.17 | 83.33                  |
|                  | Average     | 75 | 75 | 75 | 100 | 75 | 75 | 81.47 | 83.33                  |

To determine the effect of using the SETS learning approach module to improve students' critical thinking skills, the scores of students' critical thinking test in the control class were compared with those of experimental class based on the size of critical thinking developed [20]. The mean and standard deviations of pre-test value of their critical thinking were 69.66 and 10.38 for the control class and 69.40 and 8.96 for the experimental group. The t test results showed that there was no significant difference in the pre-test value of the critical thinking of the two groups with p-value = 0.915 (p > 0.05), implying that both classes of students had equal critical thinking skills before participating in the learning activities.

After the learning activity, the final value or post-test of critical thinking in both classes is taken. Table 3 shows the t-test results of the post-test value of the two classes. It was found that group post-test values differ significantly with p-value = 0.004 (p < 0.05). In addition, the mean post-test grade of the experimental grade (84.11) was higher than the control class (77.86), indicating that the students in the experimental class demonstrated a much better critical thinking ability than the control group. Consequently, it was concluded that the SETS approach module had helped students in improving their critical thinking skills.

Table 3. The Differences in The Ability to Think Critically on Posttest Values of Both Groups

| Groups          | N  | Mean | SD  | p-value | n-gain |
|-----------------|----|------|-----|---------|-------|
| Control class   | 32 | 77.86| 9.19| 0.004*  | 0.27  |
| Experimental class | 32 | 84.11| 7.36|         | 0.47  |

*Independent sample t-test

An analysis to know the effectiveness of learning module by using gain score for control class post-test and experiment class. Gain score was good indicator to show the effectiveness in learning. Based on the calculation of n-gain scores, the control class obtained a value of 0.27 (low), while for the experimental class had a value of 0.47 (medium).

The data of students' responses were used to obtain students' opinions about the feasibility of the ecosystem theme module with the SETS approach applied in the learning process. Questionnaire given to 32 students in class VII D (experimental class) which covered two statements that were positive and negative statements. The number of positive statements there were 11 items and negative statements were 10 items. The response of the students in class VII D answered strongly agree on the positive statement with the average gain of 3.47 which means the module was very good and feasible to use,
whereas in the negative statements, the students answered strongly disagree with the average gain of 1.58 which means the module was also very good and decent. In addition to students, teachers also provided an assessment of the development of the natural science module with SETS approach. The results of the assessment and response of the average science teachers amounted to 3.73 included in the category of very good and feasible to be used.

3.2 Discussion
The first stage was the definition through field observation by spreading the questionnaire to analyze the needs of teachers and students conducted at schools. The results showed that the learning process to train critical thinking skills had never been taught, the students still needed direction from the teacher, the learning process was only centered on the teacher. In addition, teachers and students lacked of learning resources to optimize their critical thinking skills. From the results of observation, it was also known that SETS approach in learning had never been done at school so that students' critical thinking skills did not maximized yet. The lessons that have been applied using team teaching but in reality, in the classroom learning process was still done alternately according to the area of expertise of each teacher.

The second stage was the design stage by drafting the draft module which consisted of the initial module design containing cover, francis page, introduction, table of contents, list of drawings, table list, introduction, learning activities (I, II and III), assessment, key answers, assessment rubrics, glossary and bibliography. The module compilation refers to the learning path of SETS, a module that contains the linkage of SETS elements and modules used in classroom learning and self-study at home. The material was presented using SETS steps, so that finally found the correlation between one concept with other concept especially related to daily life. It was done so that students could think critically, so that it could relate between the concept that had been accepted with daily life, made wrong in making decisions and made learning more meaningful.

In the third stage was the development stage which included the initial product validation results in the form of draft module, it was a module that had been assessed by experts, education practitioners and peers. Validation is a process to test the suitability of the module with the competencies that are the target of learning. If the content of the module is appropriate, the meaning is effectively used to study the competencies which are the target of learning, then the module is said to be valid. However if the validation result states invalid, then it needs to be repaired until the module has valid category [12]. Based on the validation result, it can be concluded that the natural science module with SETS approach was feasible to be used in learning. After the validation of the product, further revisions were made, based on suggestions and inputs from reviewers, the weaknesses that found in the module design were then improved, so that the module that had been developed, had paid attention to the ease, and clarity for students in studying the material independently.

In accordance with the purpose of making modules is to train the independence of learners, reduce the role of teachers in learning activities, train students honesty, help learners to measure the mastery of learning materials, and the last is to accommodate the various levels and speed of learning learners. The preparation of this module had also paid attention to the purpose of composing the module itself, but there was one objective that could not be achieved with the preparation of this module. To determine whether this module could be said as a teaching material that was able to accommodate the various levels and speed of learners, it is necessary to test the use of this module in the actual class [21].

Learning modules could help learners to build what they learn and understand and facilitated their active participation in the learning process. Modules could be studied independently and also have a specific theme. It could give students the information necessary to acquire and assess the knowledge and skills specified. The modules require students to actively interact with learning materials, not just passively reading the material only. Students were asked to do various things in the learning activities and got feedback about what they do. Some types of evaluation strategies presented in the module told the students whether they achieved full mastery of the material and what to do if they could not
achieve the required mastery [22]. It is known that one of the functions of the module was as a student guide in self-study, so that basic skills matched the needs and abilities of students in elementary education stage [23].

Implementation of Natural Science module with SETS Approach was conducted to determine the feasibility and effectiveness of the module itself. Module eligibility could be seen from the responses or responses of students and teachers after using the module. The effectiveness of the module could be seen from the improvement of students' critical thinking skills after using the module. In a large-scale trial of data analysis used to determine differences in critical thinking skills in the control class and experimental class using prerequisite test that was normality test, homogeneity test and t-test.

Based on the prerequisite test results, the hypothesis test using parametric statistical test that is t-test Independent Sample t-Test. In the p-value of 0.004, the significance level of $\alpha = 0.05$ ($p <0.05$), the result of the analysis of critical control thinking skill score and experiment class found that there was a significant difference between the control and experiment class scores. Which was significant between students' critical thinking skills between classes that used modules with classes that did not use modules. Significant differences in the use of the SETS approach natural science module with the ecosystem theme in the product testing class (experimental class) presented positive results because learners were interested in learning to use natural science module. In addition, the use of modules also has a positive effect on students' critical thinking skills.

The effectiveness of this module could be seen from the n-gain results for the post-test of control class and the experimental class, based on the n-gain results in table 3 it could be explained that the effectiveness of the experimental class (0.47) was higher than the control class (0.27). This proved that learning using natural science module with SETS approach was more effective to improve students' critical thinking ability compared to conventional learning using borrowed books from school (Electronic Books package from school).

Through critical thinking, students could be taught to critically examine different perspectives on issues regarding the impact of science and technology on everyday life, and to evaluate these issues from a social and environmental perspective. The encouragement of science by educators for students in critical thinking about science and technology, would also help to develop their analysis, skills, and abilities to make informed choices in everyday life [8].

According to the literature review, most research emphasizes that thinking could be taught. In other research findings indicated that life skill training could emphasize positive effectiveness and increase critical thinking of students in primary school. This finding also indicated an increase in the critical thinking subscale of the experimental group [24]. The students' critical thinking skills will be developed by working together in small groups. It was indeed necessary to attempt to teach the thinking skills and the contents of integrated thinking and curriculum strategies [25].

After the learning activity which done using the module had been completed, students were given a questionnaire that contained the responses, feedback and assessment of the module. The result of the overall students' response was excellent and the module was feasible to use. Learning using modules with the SETS approach was able to cultivate students' curiosity, provided new information, and encouraged students to seek additional information that is further evidenced by student responses. During the learning process students actively answer questions from the teacher. Discussion process was also done by students by actively searched information through library or internet sources.

The fourth stage was disseminate, at this stage was done by spreading of modules in the 5 junior high schools in the District Jatisrono, Wonogiri regency. The distribution was done to the science teacher and then given a questionnaire containing the teacher's response to the developed module. Teacher response results were used to elicit teachers' opinions on the feasibility of ecosystem modules with the SETS approach developed by using teacher response questionnaires. The overall teacher response outcomes were excellent and the modules were eligible to use. Modules with communicative language and examples or images contained in the module, could not be denied to provide a very large message for student learning outcomes, the number of images clarified with the description of the material would make students interested to learn the material ecosystem. With the interest of students
on the material that had been taught, then the students would be more motivated to get a better value. Teachers also provided a positive response that the module could be studied independently and anywhere.

4. Conclusions
Based on the result of research, it can be concluded that the quality of module based on the module validation result Natural science with SETS approach on the theme of developed ecosystem included in very good category, while based on the responses of students and teachers, it showed that the module was very good and feasible to be used. Natural Science module with SETS approach on ecosystem theme was effective to improve students' critical thinking ability based on N-gain score of 0.470 showing medium category.

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