VALIDITY AND PRACTICALITY OF BIODIVERSITY TEXTBOOKS BASED ON *SCIENCE, TECHNOLOGY, ENVIRONMENT, SOCIETY* (STES) TO TRAIN STUDENTS' CRITICAL THINKING SKILLS

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Abstract

A textbook development research on biodiversity topic was aimed to make a valid STES-based (*Science, Technology, Environment, Society*) biodiversity textbook for training students' critical thinking skills which were assessed through the contents, presentations, and linguistics. The method used for this research was ADDIE development models, validity, and readability. Validity was tested by an educational expert, a biodiversity expert, and a 10th-grade biology teacher. The readability obtained by determining its' readability level based on a Fry Graph, which was counting the number of sentences and syllables of 100-words sample. The result showing that a STES-based biodiversity textbook is appropriate for training 10th-grade students' critical thinking skills. Validity was interpreted as highly valid at a score of 3.73. The textbook's readability score was at the 10th level, which means that a biodiversity textbook is proper to be read by 10th –grade students.

Keywords: textbook, biodiversity, STES, critical thinking.

INTRODUCTION

21st Century Global Competition required every productive-aged person (workforce) to have global competencies, which were communication, collaboration, creative, innovative and critical thinking skills to solve daily problems effectively (Zivkovic, 2016). Critical thinking ability was observed through reading and writing statements about daily life by involving simple mathematics and science (UNDP, 2015; Gojkov, 2015). The 2015th PISA (*Program for International Study Assessment*) report published that the scientific literacy skills of Indonesian students was at the ranked of 64 out of 65 total participated countries. This result was reinforced by the 2015th UNDP (*United Nations Development Program*) report that Indonesia's HDI (*Human Development Index*) position was ranked at 111 out of all countries that are members of the UN (*United Nations*) with the value of literacy skills in reading, mathematics and science were 396, 375 and 382. Based on the 2016 OECD (*Organization for Economic Co- operation and Development*), this value was still far from the average literacy reading, mathematics and science which are respectively 496, 494 and 501. Therefore literacy, science, and mathematics literacy

skills need to be developed to increase Indonesian students' critical thinking skills.

Curriculum development in the educational field was carried out to fit the era and global competition in the future (Vong and Kaewuray, 2017). Global competition required each individual to have the multidimensional ability, to check and understand the existing phenomena to take action (Ennis, 2011; PISA, 2018). The purpose of this change was balancing between students' *hard skills* and *soft skills* as a provision to compete in the future which includes curriculum concepts, books used, learning processes and assessment processes (Ministry of Education and Culture, 2014).

Biology textbooks used in high school learning should be systematically arranged to be easier to use and to attract readers. The important things of developing textbooks were the contents, presentations, and linguistics (BSNP, 2014). Science, Technology, Environment, Society / STES are the integration of science learning to achieve scientific literacy, answer global challenges and curriculum goals (Zoller, 2013; Ministry of Education and Culture, 2014, BSNP, 2014). Another goal of integrating the STES components was to develop knowledge and improve critical thinking skills through analyzing and decisions making to advance education in a sustainable manner (Zoller, 3013). Critical thinking can be honed through reading, science, and mathematics. Student-centered learning processes that focus on how students learn to "think" with a reflective approach are more effective than teacher-centered learning because students experience learning processes critically from real to abstract (Anderson and Krathwohl, 2014; Pleschova and McAlpine, 2015). Therefore, there is a need for textbooks that link the elements of science, technology, environment and society in daily life, which was close to students.

The availability of textbooks as teaching materials supporting the learning process was quite easy to obtain, but the availability of textbooks based on *STES (Science, Technology, Environment, Society)* was not. Based on observations made at Hang Tuah 2 Sidoarjo High School, the textbook used was unable to attract students' interest in reading. The contents of the book were too much reading material, difficult terms, few students' activities features and had not shown the links between science, technology, environment and society/ STES. Research by Ilmi (2017) and Susanti (2018) stated that STES literacy-based textbooks receive very positive responses, so these kinds of textbook could be used to practice students' scientific literacy skills and critical thinking.

Indonesia's biodiversity richness was very high as well as its endemic level of flora and fauna (Kusmana and Hikmat, 2015). Exploration and used (consumed) by humans could be a threat to the preservation of Indonesia's biodiversity. Through the integration of Science, Technology, Environment, Society (STES) with KD 3.2 and 4.2 revised 2013 curriculum, students could practice thinking critically on the current phenomenon of biodiversity. By analyzing, differentiating and interpreting biodiversity problems, students were expected to critically suggest biodiversity conservation efforts.

Based on the description above, the aim of STES-Based (science, technology, environment and society) biodiversity textbook development to Train X[th]-grade students' Critical Thinking Skills was to produce valid STES-based biodiversity textbooks, which expected could attract students' reading interest and become an effective learning source for teachers to practice critical thinking skills.

METHODS

The textbook was developed by using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) (Sink, 2014). The

properness of the textbook was determined by experts' validation, and readability was based on a readability test on the Fry graph.

The Analysis stage of the ADDIE model was to analyze curriculum (the appropriate basic and core competence), students, assignments, concept/ material, formulate the indicators and learning objectives. The Design stage was to design STES-based textbooks on biodiversity concepts. The Development Phase was aimed to produce STES-based biodiversity textbook based on the validity, critics and suggestions of academic experts (lecturer). Implementation phase was conducted to find out the practicality of STES-based biodiversity textbooks, by testing the textbooks limitedly to 16 Xth-grade students of MIA-1 Hang Tuah 2 Sidoarjo High School. Evaluation stage was conducted based on students' responses after using STES-based biodiversity textbook.

The validity of STES-based textbooks was determined by the properness between the contents and learning objectives. The validity was reviewed based on validation processed by education experts, biodiversity experts and Xth-grade biology teacher of Hang Tuah 2 Sidoarjo High School by using STES-based textbook validation sheets. Biodiversity textbook stated valid if scored > 2.51 (Arikunto, 2003)

Readability is the textbook suitability level based on students' reading abilities and learning implementation. Readability was tested based on the Fry Graph, then it would be analyzed descriptively by the author. Readability data was obtained by taking sample paragraph contain of 100 words in the textbook. The level of readability was determined by counting the number of sentences and the number of syllables of those 100 words, then converted into Fry graphs. If the number words in a paragraph was <100 words, the number of sentences would be added by conversion numbers and the number of syllables would be multiplied by the conversion number as shown in table 1. Then the syllables are multiplied by 0.6 since the texts were written in Indonesian.

The textbook readability would stated appropriate as if the intersection of the vertical lines (indicated the number of sentences per 100 words) and the horizontal lines (indicated the number of syllables per 100 words) were at the level of 10.

Table 1. Conversion Number for Paragraph less than 100 words

Number of Words	Conversion Number
30	3,3
40	2,5
50	2,0
60	1,67
70	1,43
80	1,25
90	1,1

RESULTS AND DISCUSSION

Biodiversity textbook has an attractive cover and features, presented in 10 book columns, named Bio Goals, Bio Term, Bio Surf, Bio Discover, Bio News, Bio Force, Bio Literacy, Bio Literacy, STES Biogram, Bio Summary and Bio Mind as shown in table 2 below.

Table 2. result of STES-Baseb Biodiversity Textbook
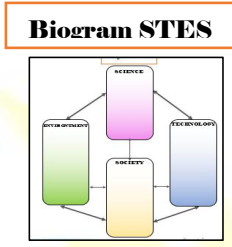
Cover and Features	Describtion
	Cover
Bio Goals	The Bio Goals column contained the learning objectives which would be achieved by students during the learning process in each sub-chapter
Bio Term	The Bio Term column contained

Cover and Features	Desc3ription
	biology terms must be known by students to understand the presented text in the book
Bio Surf : interpretasi	The Bio surf column guided students to surf the internet to find out more information about the topics in each sub-chapter
Bio Discover: inferensi/	The Bio Discover column guided students to do activities by observing surrounding environment or the presented phenomena. This activity was aimed to train one component of critical thinking, this could be inference or interpretation skill.
Bio News	The Bio News column presented texts/ articles of updated issue related to the sub-chapter which being studied
Bio Force: interpretasi/	The Bio Force column gave reinforcement material so students could understand what has been learned better. This activity aims to strengthen the training of one of critical thinking component, inference or interpretation
Bio Literacy: analisis	The Bio Literacy column contained texts of biology issues which the STES Component would be analyzed by students.

Cover and Features	Desc3ription
	Students would present each STES Component in STES Biogram. This activity was aimed to train students' analytical skills
Biogram STES	The STES Biogram column asked students to identify the components of science, technology, environment and society from the text/ article given
Bio Summary	The Bio Summary column contained a summary of the sub-chapter that had been studied.
Bio Mind	The Bio Mind column asked students to admire the regularity of God's creation so that they could always be grateful.

The validity results of STES-Based Biodiversity Textbooks are presented in table 3 below.

Table 3. Validity of STES-Based Biodiversity Textbooks

Number	Assessment Criteria	Score	Interpretation
1.	**Contents**		
	Textbook materials are appropriate to both basic and core competencies	3.83	highly valid
	Materials' scope and accuracy	3.67	highly valid
	Up to date	3.78	highly valid
	Develop skills and stimulate curiosity	3.89	highly valid
	Updated features	4	highly valid
	Activities in the Textbook	3.53	highly valid

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	Criteria and components of STES-Based (Science, Technology, Environment, Society) textbook	4	highly valid
	Stimulate and Train Critical Thinking Skills	3.67	highly valid
	Average	3.7	highly valid
2.	**Precentations**		
	Precentation technic	3.89	highly valid
	Support concept precentation	3.33	Valid
	Textbook form	3.67	highly valid
	Average	3.67	highly valid
3.	**Linguistics**		
	Language used	3.5	highly valid
	Structures	3.5	highly valid
	Average	3.5	highly valid
	Average of Validity	**3.73**	**highly valid**

Textbook readability was calculated by taking a sample of 100 words as the sample shown below:

Paragraph 1 page 6

"*Keanekaragaman hayati tingkat spesies merupakan adanya variasi yang tampak pada spesies satu dan spesies lainnya yang ada di suatu habitat atau ekosistem tertentu dalm genus atau family yang sama. Untuk dapat memahami pengertian ini marilah terlebih dahulu kita mendefinisikan apa itu spesies. Secara biologis spesies merupakan individu-individu sejenis yang mampu berkembangbiak menghasilkan keturunan yang fertil. Secara morfologis spesies merupakan sekelompok individu yang mempunyai beberapa karakter khas yang membedakan dengan kelompok individu lain*"

*words: 72; sentences: 4; syllables: 207; conversion number: 1.25; thus, number of sentences: **5.25** and number of syllables 258.75 X 0.6= **155.25** interpreted at the level of 10 on Fry Graph*

Interpretation of the sample above shown on the Fry Graph below:

Fry Graph for estimating Reading Ages (grade level)
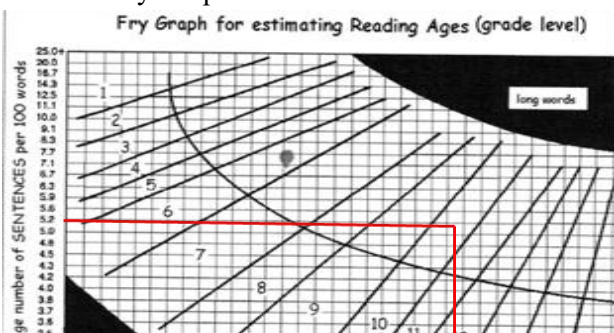
Graph 1. Readability level of 1st paragraph, page 6

STES-based Biodiversity textbook was represented through samples, which described in table 3 and graph 2 below.

Table 3. Description of textbook readability
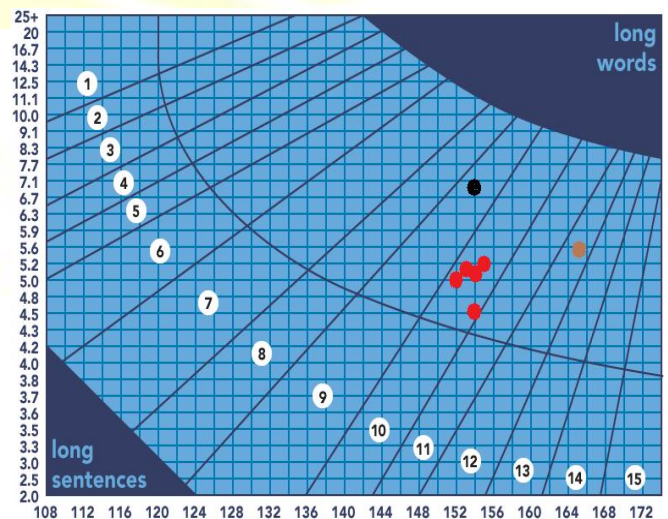
biodiversity benefits and conservation on biodiversity was appropriate to Basic

competency 3.2 and 4.2. The scope and accuracy of presented material in the textbook were appropriate to learning objectives and learning indicators in Bio Goals column for each subchapter. Through the examples given in Bio Mind column in each subchapter were supported spiritual attitudes development, (Core Competency 1) to live and practice the teachings of their religion, and social attitudes (KI 2) responsible, responsive and proactive towards problems and can position themselves as a reflection of the nation in the world association (Ministry of Education and Culture, 2014). Biodiversity issues which presented in the textbook were up-to-date and could stimulate curiosity, because the issues reflected the latest conditions and taken from news/ articles published less than the last 5 years. One of the BioNews columns titled "The Area of the Indonesian Seagrass" page 48 and one of the Bio Literacy columns titled "Emergency of Forest and Land Fire, Haze Disasters Preventing Primate Life" and "Knowing Calcium Oxide for Weather Modification in the Management of Forest and Land Burn " page 56, were taken from leading newspapers and online media published in 2018 and 2019. Besides, one of Bio Surf columns on page 10, students were asked to access news about discovery of 2 new orchid species by LIPI scientists through the links given. The suitability of the book material with the learning objectives presented in up-to-date and interesting features was expected could increase students' curiosity and interest in reading, so that students' interest in learning would be increased too. Good teaching materials ware able to stimulate student curiosity, contain detail material which was appropriate to science development and relevant to the circumstances around to avoid misconceptions (Djahir and Pratita, 2015; Katun and Budiawati, 2015).

Each activity in each textbook's subchapter could enlarge student's knowledge, easy to followed and identified its STES components, also could trained critical thinking skills. Activity "determining the dominant plant species of an area" in Bio Discover column page 11, students were trained to think critically by using evidence and phenomena to conclude (inferences). Students were asked to list the types and number of plants in an area of 50 x 50 cm, then they were determined what plants had been dominated that area by using Simpson Dominance Index. In this activity students had trained the scientific method of formulating the problem "how was the plant dominances in the school yard ecosystem, observing what plants planted in the school yard, collecting data of types and numbers of plant species and analyzing the data of dominance index to make the conclusion. *Science* component of this activity was the levels of plant biodiversity in the school yard ecosystem. *Technology* component was plot of 50x50 cm, which used as sampling methods, has not to count all the plants existed at school yard, while the *environment* component, school yard itself, was dominated by clovers and soil which used as a habitat for several types of insects. *Society* components, meniran plant, it was not only weeds but also could be used as medicine. If students could conclude what species dominated the school yard ecosystem, students had thought critically by inference indicators. Through student-centered learning students could arrange their knowledge, communicative, making decisions and taking action to solve problems (Zoller, 2013; Ministry of Education and Culture, 2014; Zivkovich, 2016; Vong and Kaewuray, 2017; Anfa, et al, 2019).

In Bio Force column page 53 titled "Diversity of the Endemic Archipelago ", students were trained to collect data (interpretation). Presented a map of the endemic fauna distribution, students were asked to identify the fauna on each of Indonesia's major islands then grouped them by Orientalist, Australian and Transitional types. After that, they would decided to determine the characteristics of each type. By doing this activity, students had trained how were the

characteristics of each fauna based on the data (interpretation). On the other hand, in Bio Literacy column page 57 titled "Emergency Forest Burn Threatens Primate Life" and "Get to Know Calcium Oxide for Weather Modification to treat Forest and Land burn" students were trained to analyze STES component of the phenomena then they would present it into STES Biogram and answer questions related to that phenomenon through group discussion. *Science* component of these two phenomena was the diversity of primate species including Lutung Berangat (*Presbytis canicrus*), Lutung Dahi (*Presbytis frontata*), Lutung Merah (*Presbytis rubicunda*) and Lutung Bekak (*Presbytis chrysomelas*). *Technology* component was the weather modification technology, the *environmental* component was a non-increased area of forest burnt, and *society* component was reducing the impact of smoke caused by forest and land burn. Through this activity students were trained to change data from text form to chart form, which means students could change data from one form to another (analysis), worked in team and to communicate. Knowledge development activities by analyzing, inferring, and interpreting problems/ phenomena around them in writing through the integration of STES in cooperative learning (discussion), students independently were trained to think critically so that the transfer of knowledge in learning process and its application to real life could be more efficient (Facione, 2011; Zoller, 2013, Tubackova, 2015; Pieterse, 2016; Zivkovic, 2016 Cargas, 2017, Anfa et al, 2019; Laily, 2019).

A textbook was a set of materials that are arranged systematically, flexibly and presented to create learning facilities for students (Prastowo, 2012; Lestari, 2013). Biodiversity textbook was designed by considering presentation feasibility, consisted of presentation techniques, supporting concept presentation and physical form which appropriate to BSNP standards. The eligibility of presentation criteria got a highly valid interpretation with an average score of 3.67, which means that textbook material was presented coherently, consistently and appropriate to the concept. The material was presented from simple to complex, materials, from subchapter of biodiversity level to conservation. If students could understand the concept of the biological level, then they would easily identify the unique characteristics of Indonesian biodiversity, how to use it wisely for sustainable development and taking action to keep biodiversity lasts long through conservation. There were supporting features presented in the column with attractive template designs and drawings, like Bio Goals column, Bio News column, Bio News column, Bio Surf column, Bio Discover column, Bio Force column, Bio Literacy column, Biogram STES, and Bio Mind column which we had discussed in the previous paragraph. Bio Summary column was supported a coherent presentation because it contained a summary of what had been learned in each subchapter and Bio Term column was contained definitions of difficult words that would be discussed in the linguistics description. Pictures, illustrations and tables already had identities such as numbering, titles and lists of sources. Textbooks were presented on B5-sized paper, with a cover that related to the material, but it was still interesting. The Combination of font, colors and font sizes was appropriate to scientific writing standards and contrast with the background so that it was easy and comfortable to read. By this presentation, it was expected to attract students' interest in reading, increase conceptual understanding and critical thinking in learning (Demirci and Ozyurek, 2017).

Linguistics criteria got an average score of 3.5 with a highly valid interpretation. That means, words used in the text were appropriate to the understanding level of Xth-grade students. Structure used in the textbook were following the standard, straightforward and dialogic, according to EYD (Enhanced Spelling) and

KBBI (Indonesian Dictionary). Some new biology terms and difficult words had been defined in Bio Term column in each subchapter so that students could understand the presented material correctly without multiple interpretations. If the sentences were easy to understand, it was expected to increase students' interest in reading so that students would also easy to understand and arrange the concept of knowledge in their minds (Lestari, 2013).

Readability in developed textbooks was based on the Fry Graph. The Fry graph was proved to be accurate in assessing the readability of Indonesian texts (Yasa, 2013). Readability was obtained by taking a sample of 100 words in a paragraph and then counting the number of words and the number of syllables of those 100 words. Number of syllables was used as the X-axis and the number of words was used as the Y-axis. Textbook readability must be adjusted to the users' level. Based on the readability results, Textbooks had a mode at the level of 10, was meant that the structure of STES-based (Science, Technology, Environment, Society) biodiversity textbooks was appropriate to the understanding level and socio-emotional development X^{th}-grade students. An appropriate level of readability with the learning level (grade) of the user showed that the language in the textbook was easy to understand, appropriate and could be used to practice critical thinking skills through readings and science (scientific literacy) (Tubackova, 2015; Himala, 2016).

Conclusion

Based on the results above STES-based biodiversity textbook was valid at the score of 3.73 and had readability at the level of 10, which means it could be used to train critical thinking of Xth-grade students.

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