The development of environmental change textbook based on STEM-Cp to improve problem-solving skills in high school biology learning

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Abstract. 21st century learning characteristics 4C (Communications, Collaboration, Critical Thinking, and Problem Solving, and Creativity), train students to innovate, skills in using the technology, media information, and skills of the workforce. The learning approach that matches the 4C character is the STEM approach. STEM is an integrated learning approach in all disciplines that trains students to innovate, and has a positive impact on learning outcomes. Although STEM-based learning has begun with its emergence the problem is in accordance with the concept, but the problem does not yet reflect the contextual problem (Contextual Problem). Learning about environmental change material even though it starts with a problem, but learning in schools only focuses on understanding the theory and literature without direct implementation in the lives of students. Based on that problem, the need for textbooks that discusses the concepts and technologies in a balanced, integrated, and include contextual problem in order to facilitate the students understand the concept of environmental changes in life. This study aims to develop a book teaching of environmental changes based STMCpE valid, effective, and practical. This research uses the 4D development method, namely Define, Design, Develop and Disseminate and mixed method which consists of quantitative and qualitative research. Qualitative research in the form of research development STMCpE-based textbooks. Quantitative research uses the pure post-test only control design experimental method. In the normality test the normal distribution of data obtained, and the homogeneity test obtained homogeneous data, so that parametric data analysis needs to be done using an independent sample t-test analysis. Based on the results of research are: (1) Development of a book teaching generated already included category valid, effective and practical, (2) Application of learning scientifically based STMCpE significant effect on the ability of solving students ' y an shown on the significance value of 0.000 (p < 0.05)

1. Introduction
Very rapid global developments due to advances in technology require the nations of the world to change their education systems. In recent years, both developed and developing countries have sought to improve the quality of education, including Indonesia. In the 21st century this time all countries are competing to improve and explore the ability of natural resources and human resources to be able to master the demands of the times in all fields of life. One that must be mastered by all countries in enhancing and exploring capabilities is science and technology. In the development of science and technology in the 21st century it brought a big change in the development of education. The change resulted in a shift in education from a teacher-centered learning (Teacher Center Learning) into a student-centered learning (Student Center Learning) and from the curriculum KTSP into the curriculum in 2013 as currently applied in Indonesia.

The 2013 curriculum aims to give birth to the next generation of the nation who are productive, creative, characterized and affective through strengthening integrated attitudes, skills and knowledge
in accordance with skills in 21st century learning, namely 4C (Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity) [1] said that in the 21st century learning design students to be able to keep up with the times by having learning and innovating skills, using technology, information media, and being able to work and be able to use skills to survive.

One of the characteristics of 4C learning that will be improved after using this textbook is Problem Solving skill. In a learning process students must be able to solve all the problems they face by building on their existing knowledge and experience. The ability of students to solve existing problems needs to be improved in the learning process. The problem-solving ability is the process of accepting the problem as a challenge to solve the problem. Problem solving skills teach students to solve problems that enable students to become more analytical in making decisions in life (Cooney et al. In [2]). In problem solving skills, each individual has the ability to solve different problems. This is related to the strategies implemented by each individual [5].

One approach that has been developed to improve the quality of education and in accordance with the 21st century skills is a learning approach based on Science, Technology, Engineering, and Mathematics (STEM). STEM is considered to have revealed a lot of successful innovations in the pedagogical field such as producing learning contexts that allow for interaction, students' learning tasks appear more in real life, and can also bring out the most substantial learning benefits for students[6]. According to[7], STEM has been highly recommended to be implemented as an integration in many disciplines, suggested that the use of the STEM approach in learning had a good impact on student learning outcomes. According to William (2011), that STEM is used to overcome real-world situations through a design-based process of problem solving as used by engineers and scientists. Morrison (2006) argues that some of the benefits of STEM education are that it can make students problem solvers, inventors, innovators, and independent, logical thinkers, technology literate, and able to connect STEM education with the world of work. So STEM based learning can be used to improve the character of 4C learning in the form of problem solving skills.

STEM-based learning can improve student learning outcomes. Suwarma, et.al. (2015), also suggested that STEM-based learning can increase student motivation and activity in the learning process. Although STEM-based learning provides problems (problems) that are relevant as stimuli (stimulants) at the beginning of learning, but the problem (problem) given is not a contextual problem or that is around the lives of students. Argues that the problem or problem that is usually contained in the STEM approach is a global problem, said that students will more easily understand the concept, if the problem given is a problem that often occurs in around students (contextual problem). So STEM-based learning already has a problem that is in accordance with the concept, but the problem does not yet reflect a contextual problem.

Problems experienced by students in their daily lives and close to students' lives are about environmental pollution. Environmental change material that has been taught in schools is only limited to literature and theory without the implementation of these learning outcomes. What does it mean there are 3 kinds of environmental change material, namely environmental change, pollution, and waste recycling.

In the STEM approach the problems faced globally while in STEM-CP combines the STEM approach with a contextual approach where contextual problems are not globally but in real terms in the environment around students and even experienced by students every day in their lives. In law number 14 of 2005 concerning teachers and lecturers, article 10 paragraph 1 states that a teacher must have several competencies, one of which is professional competency, that is, educators are required to have a high professionalism spirit, including the ability to develop teaching materials.

Teachers are expected to be able to choose the right teaching materials in the learning process, especially in science learning. Learning material is a set of material that contains learning material or content that is designed to achieve learning objectives. Teaching material is systematic meaning it is arranged in order so that it makes it easier for students to learn. Teaching materials that must be owned by educators in the learning process are textbooks.
Textbooks are classified as one of the teaching materials that play an important role in the success of the learning process. Textbooks are a unit of learning unit that contains information, discussion, and evaluation. The availability of textbooks will facilitate and accelerate the realization of student-centered learning (SCL) programs [10-20]. Basically the characteristics of learning based on the 2013 curriculum which are in line with the characteristics of 21st century learning are emphasizing student-centered learning, and the task of the teacher as a facilitator of student learning processes. However, most learning still tends to be teacher-centered learning, generally done nominally and declaratively [9]. This can cause the low cognitive development of students regarding the concept of science, especially Biology. One reason for the low cognitive abilities of students is the learning tools including the use of media in the process of teaching and learning activities[8].

The use of instructional media allows increased communication in the teaching and learning process, so that it can run smoothly with maximum results [7]. Thus, instructional media including textbooks contribute to the achievement of objectives during Biology learning

2. Method

This study uses a Mixed Methods method with a Sequential Exploratory Design model, a method that combines sequential qualitative and quantitative research methods [1 3 ]. The development of this learning tool uses the Thiagarajan, Semmel & Semmel (4-D) development model which consists of four stages namely define, design, develop, and disseminate [ 4 ]. this research development aims to develop a book teaching material environmental changes based on learning approach STMCpE Biology in high school.

The independent variable of this development research textbook is STEM-Cp based environmental change and its dependent variables are validity, effectiveness, and practicality. The validity of this textbook uses validator validator experts and users by using sheets of validation instrument validation of legibility, language, grain and graphic value to valid if the score validator reaches at - least 70% or categorized quite valid.

The practicality of this textbook is seen from the use of textbooks in learning known from the implementation of learning in accordance with the syllabus and RPP using observation instrument sheets have an average score of observer assessment - at least 60 observers and also known from the questionnaire students responses to textbooks at least included in the category of interesting and quite practical by using a questionnaire instrument sheet that scores an average rating of at least 41 pounds.

The effectiveness of textbooks is known from the value of problem solving skills that must be mastered by students. If a book teaching and research instruments dinyat a right valid, practical and effective, it can be used in learning. But if the textbooks and research instruments are still not valid, practical and effective, then it needs to be revised in accordance with input from the validator. After collecting data in the form of test results and instrument sheets, the normality assumption test is then performed using the Kolmogorov-Smirnov test and homogeneity of variance using the Levene's test.

Each test for normality and homogeneity of variance with a significance level of 0.05 (P <0.05). T-test is done if the data is normally distributed and homogeneous, but if the data is not normally distributed or non-homogeneous then it uses the Mann-Whitney test. The development research procedure is illustrated in the following figure.
Figure 1 The Experiment Research

Population
This research was done in class throughout X SMAN 1 Lumajang in even semester of the year lesson 2019/2020. The sampling technique used was random sampling of 9 students with different levels of ability (smart, medium, and less smart) for small class tests. The large class test randomly selected two classes, the first class was an experimental class with the application of STMCpE-based learning consisting of 20 students, and the second class was class control with the application of direct instruction consisting of 20 students. As for the dissemination (distribution) using 3 different schools with 3 different districts as well. After testing the validity, practicality, effectiveness, and test the ability of problem solving in students, then the normality test is carried out using the Kolmogrov-Smimmov test and homogeneity of variance using the Levene’s test. Test for normality and homogeneity of variance at a significance level of 0.05 (P <0.05). The t-test is done if the data is
normally distributed and homogeneous, but if the data is not normally distributed or not homogeneous, the Mann-Whitney test will be conducted. Instrument

The instruments used in this study were tests of students' problem solving skills, interview analysis of student and teacher needs, and instrument validator sheets. The validity instrument sheet is the validation of the textbook content, the validation of the textbook presentation, the language validation, and the graphic validation. Practical instrument sheets in the form of documentation of student response questionnaires and observations of learning practices while using the STEM-Cp-based environmental change textbook. The effectiveness sheet is the students' pretest and posttest scores in problem solving before and after using the STEM-Cp textbook. A description of the experimental research procedure is illustrated in the following chart.

![Experimental Research Procedure](image)

**Figure 2:** Experimental Research Procedure.

3. Results of data analysis

The process of developing STEM-Cp textbooks includes validity, practicality, effectiveness, and the value of problem solving abilities that are carried out on the experimental and control classes. In stages planning, namely asking for suggestions and input from fellow teachers High School OF 1 Lumajang and lecturers related to the process of preparing the textbooks to be used. Problem solving skills tests are given at the pre test and post test in the control class and the experimental class with the aim of obtaining data on enhancement students' problem solving abilities. The research instruments, namely the student activity observation sheet, the validity instrument sheet, practicality, and effectiveness, and the student response questionnaire were also validated. The validation process was carried out by 3 validators, namely 2 lecturers of science education and a science teacher at SMAN 1 Lumajang. The overall results of the validation of the textbooks and research instruments can be presented in Figure 3 below.
The results of the validation of textbooks and learning instruments.

In the picture above shows that the results of STEM-Cp-based environmental change textbook validation and instrument have an average value of validity (Vr) is 4 Vr <5, so it can be concluded that the so it can be concluded that STEMCp based textbooks are classified as valid categories.

The next stage is the stages of the implementation of learning by using STEM-Cp-based textbook media carried out in Class X IPA of SMAN 1 Lumajang with the subject of environmental change. This stage consists of 7 meetings, namely 5 times learning, and 2 times the activities of giving tests (pretest and posttest) in the control class and the experimental class, the difference is in the control class using direct learning. The pretest test consisted of 5 questions conducted at the beginning of the meeting and at the beginning before learning began in class for 30 minutes both in the control class and the experimental class. Pre-test activities aim to measure the initial ability to solve problems before the implementation of learning.

In the experimental class given treatment in the form of learning using STEM-Cp based textbook media which was carried out at the 2nd to 6th meeting. In the learning activities students formed groups of 3 to 4 students in each group to work together in conducting learning activities. The stages in this learning include; (a) observing, (b) asking, (c) collecting information (trying), (d) reasoning (associating), (e) communicating. This course will be different from the control class in the form of direct learning and students are only given exercises and then discuss them together. In STEM-Cp-based learning that learning covers science (science), technology, engineering, mathematic, and contextual problems where the child will learn about environmental change material raising issues that are close to students' daily lives, such as the case of forest fires that will be studied scientific knowledge as a component of science, using technology in dealing with these contextual problems, mathematics for calculating the effects of fire on the air capacity in the human lungs, and designing simple tools to deal with the impact of problems caused by environmental changes.

In the textbooks also presented practice questions that can measure the ability of problem solving in students. The results of pre-test students are shown in table 2 below. The next stage is the stages of the implementation of learning by using STEM-Cp-based textbook media carried out in Class X IPA of SMAN 1 Lumajang with the subject of environmental change. This stage consists of 7 meetings, namely 5 times learning, and 2 times the activities of giving tests (pretest and posttest) in the control class and the experimental class, the difference is in the control class using direct learning. The pretest test consisted of 5 questions conducted at the beginning of the meeting and at the beginning before learning began in class for 30 minutes both in the control class and the experimental class. Pre-test activities aim to measure the initial ability to solve problems before the implementation of learning.

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| Class     | Total students | Highest Score | Lowest Value Score | Average | Std. Deviation |
|-----------|----------------|---------------|--------------------|---------|----------------|
| Experiment | 18             | 7.58          | 1.17               | 26.14   | 16.30          |
| Control   | 18             | 7.58          | 1.17               | 26.16   | 16.32          |

Based on table 1 above shows the maximum score of pretest in the experimental class is 7, (the category is quite capable of solving problems ) and the minimum score is 1.17 (category of not able to solve problems ) with an average of 26.14 (SD = 16.30). Whereas in the control class, the maximum pretest score was 7.58 (the category is quite capable of solving problems ) and the average mini score was 1.17 (the category was not able to solve problems ) with an average of 26.16 (SD = 16.32). The average difference between the two classes is also not much different. The number of students based on the category of students with the ability to solve problems in the control class and the experimental class showed the same number of 15 students in the category of not being able to solve problems and 3 students with categories capable enough of solving problem.

| Value Criteria | score |
|----------------|-------|
| Unable solve the problem | <5 |
| quite capable solve the problem | 5-8 |
| able to solve the problem | 9 - 12 |

| Table 3. Posttest Result |
|--------------------------|
| N | Minimum | Maximum | The mean | Std. Deviation | Classical Completeness Percentage |
|--------------------------|
| Experiment class test post | 18 | 56.00 | 100.00 | 87.0000 | 13,81815 | 89% |
| Control class post test | 18 | 44.00 | 85.00 | 70.6667 | 14,02938 | 72% |
| Valid N | 18 |
In table 3 explains that the maximum value of the posttest problem-solving ability in the experimental class is 100 with an average value of 87 (Sd = 13.82) and the completeness of the class is 89% including the category of students very capable of solving problems and in the control class the maximum value of the posttest problem-solving ability is 85 with an average of 70.6 (sd = 14.0) and completeness of the class 72% category is very capable of solving problems. Both of these data do not show much difference, only 15 points. So the STEM-Cp textbook is said to be very valid.

Table 4. Recapitulation of Number of Students in Accordance with Categories

| Class         | Not able to solve problems | Quite able to solve problems | Able to solve problems |
|---------------|----------------------------|-----------------------------|------------------------|
|               | amount | Percentage | amount | Percentage | amount | Percentage |
| Experiment    | 0      | 0%         | 8      | 44%        | 12     | 56%        |
| Control       | 13     | 72%        | 0      | 0%         | 7      | 18%        |

Table 4 explains about the recapitulation of students with problem-solving ability categories found that the experimental class 0% with the number of students 0 categories unable to solve problems, 44% with the number of students 8 categories sufficiently able to solve problems, and 56% with the number of students 12 being able to solve problems. Whereas in the control class 72% with the number of students 13 categories were not able to solve problems, 0% with the number of students 0 categories were quite capable of solving problems, and 18% with the number of students 7 were able to solve problems.

It can be explained that the posttest score of students has a difference in problem solving skills because the experimental class after using the STEM-Cp textbooks the problem-solving ability increases with a percentage of 56%, whereas in control classes whose learning does not use the STEM-Cp textbooks the ability to solve the problem is only slightly 18%.

The prerequisite test is the first step of data analysis before testing the hypothesis which includes the normality test using the Kolmogorov-Smirnov statistic and the homogeneity test using the Levene's test. The prerequisite test is the first step of data analysis before hypothesis testing which includes a normality test using Kolmogorov-Smirnov statistics and a homogeneity test using Levene's test. This data analysis aims to determine the effect of STEM-Cp based textbooks on students' problem solving skills. The following is the normality test results presented in table 5.

Table 5. Kolmogorov-Smirnov Normality Test

| Class               | Kolmogorov-Smirnov a |
|---------------------|----------------------|
|                     | Statistics | Df | Sig. |
| experimental class pretests | .175       | 18 | .152 |
| pretest control class         | .176       | 18 | .147 |
| experimental class postes    | .115       | 18 | .183 |
| control class postes         | .112       | 18 | .192 |
Based on table 5 above, it can be seen that the significance value of problem solving skills in students from both classes (experimental and control). In the experimental class the pretest sign = 0.152 and the control sign pretest = 0.147, while the posttest value of the experimental class sign = 0.183 and the control class sign = 0.192, thus it can be concluded both the pretest and posttest values of the two classes (experimental and control) are normally distributed because the significance value is more than 0.05 (p > 0.05). Homogeneity test results on the pretest and posttest values can be presented in Table 6 below.

Table 6. Levene’s Homogeneity Test

| Levene Statistics | df1 | df2 | Sig. |
|-------------------|-----|-----|------|
| Pretest           | .019| 1   | 34   | .890 |
| Posttest          | .007| 1   | 34   | .934 |

Based on table 6 above, it can be seen that the homogeneity test results for the ability to solve problems in students show a significance pretest value of 0.890 and a significance posttest value of 0.934. the same value has a significance of more than 0.05. Thus the data analysis is required using the parametric test that is the Independent sample t-test. The results of data analysis are shown in table 8.

Table 7. Data analysis with independent sample t-test

| Post-test | Mean difference | Std.Error Difference | Df | Sig. (2-tailed) |
|-----------|-----------------|---------------------|----|-----------------|
|           | -50.77778       | 3.76883             | 34 | .000            |

Table 7 above shows the significance value of 0.000 (p <0.05), it can be concluded that there is a significant difference in the improvement of problem solving abilities in both experimental and control class students. Here is presented a picture 2 on the average increase in the ability of solving problems in each of these aspects in the experimental class and control class.

Figure 4. Average Results of Improvement of the Capability Aspect

Figure 4 shows that there was an increase in students' ability to solve problems from both classes (experimental class and control class), but a more significant increase occurred in the experimental class than in the control class. This increase occurred in four indicators of problem solving ability.
4. Discussion
Improving problem solving skills in students requires media to encourage them to think and practice innovating to find ways to solve problems. So that STEM-Cp based textbooks have a great opportunity to help students think and practice innovating to find ways to solve problems in understanding their learning process. The findings in the control class are known to the level of problem solving ability of students 72% in the category of not being able to solve problems, 0% in the category of being able to solve enough problems, and 18% in the category of being able to solve problems. While in the experimental class it was found that there were no students whose level of problem solving ability was in the category of not being able to solve problems, 44% were in the category of being able to solve problems, and 56% in the category of being able to solve problems. Based on the results of the analysis of the independent sample t-test, the significance value is 0.00 (≤0.05), which means that there is a significant increase in the effect of the experimental class.

5. Conclusions
Judging from the general review and analysis of the data, we can conclude that the STEM-Cp-based textbook on environmental change material in class X SMA is valid, effective, and practical. In addition, the development of this textbook also has a significant influence on students’ problem solving abilities and there is a significant improvement in the experimental class.

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