Future Physics Learning Materials Based on STEM Education: Analysis of Teachers and Students Perceptions

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Abstract. Lately the industrial revolution era 4.0 has become a discourse in various fields. One of them is education. The education sector is the front guard of the country. In the field of education, there needs to be a plan that is structured in the making of teaching materials because teaching materials are the main learning for students. This study aims to describe and analyze teachers and students on the national curriculum teaching materials based on Science, Technology, Engineering, and Mathematics (STEM). The study was involving grade XI 233 senior high school students and 3 physics teachers. The method is used in this study with sequential explanatory. The research instrument used questionnaires, interviews and Focus Group Discussions (FGD). The results showed that to support STEM learning in national curriculum needed teaching materials to include lesson plans, books, animation, stimulation, and video. Components of book teaching materials include core competencies, basic competencies, indicators, objectives, concept maps, pictures, videos, animations, material that is explained in detail in each chapter, detailed discussion, internet links, summaries, and questions. The video components include core competencies, basic competencies, goals, indicators, abducting, using everyday language, complete materials and easy to understand. The material needed to develop teaching materials in physics between stationary waves, dynamic and static electricity, temperature and heat and Newton law. All teaching materials are expected to be based on e-learning or mobile learning. In the national curriculum, the teacher has not started STEM-based teaching materials. So in the future, there needs to be the development of STEM-based teaching materials to support the national curriculum that is designed to the maximum.

1. Introduction

The industrial revolution era 4.0 became a discourse in various countries, one of which was Indonesia [1–3]. Every country needs the readiness to face the industrial revolution era 4.0 in various fields, especially education [1]. The field of education as the front guard of a country [4]. Education needs to provide the best facilities so that the learning process is in accordance with the teacher's process standards [5] so that later competent graduates will be produced, who are ready to compete in the global world [6-7]. One factor that determines competent graduates is teaching materials [8].

Teaching material is an important factor in supporting the learning process [9]. Teaching material is a material or subject matter that is systematically arranged that is used by the teacher and students in the learning process [10–12]. Types of teaching materials based on the subject consist of: (1) teaching materials that are intentionally designed to study like (books, handouts, student worksheets and modules); (2) teaching materials that are not designed but can be used for

learning such as newspapers, clippings, films, advertisements, or news. In addition, the Directorate of secondary school development and above classify teaching materials into four categories, including: (1) visual teaching materials, among others books, handouts, student worksheets, modules, brochures, leaflets, wall charts, photos and models / models; (2) Audio teaching materials include cassettes, radio, vinyl records, and audio compact disks; (3) audiovisual teaching materials for video compact disks and films; (4) computer-assisted instruction (CAI) interactive multimedia teaching materials, compact disk (CD) multimedia interactive learning and web-based teaching materials. The teaching materials that have been grouped must be in accordance with the teacher's curriculum.

Indonesia currently uses national curriculum namely 2013 curriculum that directs students to support 21st-century abilities, namely Communication, Collaborative, Critical Thinking, and Creativity [13]. 21st-century learning requires teachers to direct their students to have creativity in managing the problems of everyday life [14-15]. One of the methods used to support creativity is by applying Science, Technology, Engineering, and Mathematics (STEM) [16-18]. The fourth approach of the aspects of Science, Technology, Engineering, and Mathematics (STEM) is a matching pair between the problems that occur in the real world and problem-based learning [19-20], but there are no teaching materials that support students to study science using the STEM approach.

This approach is able to create a cohesive learning system and active learning because all four aspects are needed simultaneously to solve problems [21-22]. The application of these four aspects of students can do the work according to the skill and can reduce the unemployment rate. STEM education has become a worldwide trend [16, 19, 21, 21]. But in Indonesia STEM has not received special attention and the unknown reality that occurred in teacher at Indonesia about the application of STEM-based teaching materials. Previous studies developed teaching materials in the form of STEM-based modules [22], applying STEM learning [23–25]. This analyzes the components that need to be in the STEM-based curriculum 2013 teaching materials for students and teacher perspectives.

2. Research Methods

This type of research is a mixed method research. The mixed method strategy was used by Sequential Explanatory Strategy. The study was conducted at Senior High School of Lampung, the subject of the XI Science grade involving 223 students and 3 physics teachers. Data collection uses an instrument questionnaire, focus group discussion (FGD), and interviews. The questionnaire was given to 223 students to find out the teaching materials used during the learning process. The questionnaire was analyzed quantitatively, FGD and interviews were analyzed using qualitative descriptive.

Table 1 Interpretation of Perceptions of Students about STEM-Based Physics Teaching Materials

Interval %	Favorable	Unfavorable
$75 < x \leq 100$	Strongly agree	Disagree
$50 < x \leq 75$	Agree	Less Agree
$25 < x \leq 50$	Less Agree	Agree
$0 < x \leq 25$	Disagree	Strongly agree

The FGD was conducted on thirty-three student this was done to find out more detailed information from the questioner. Students were divided into 3 groups. High, Intelligent, Middle Intelligent, and Low Intelligent. Each group is as follows:

Table 2 Code of Focus Group Discussion (FGD)

Group Name	Number of FGD Participants	Code
High Achievement	11	HI
Middle Achievement	11	MI
Low Achievement	11	LI

Interviews were conducted on 3 physics teachers to find out the teaching materials that are often used in learning. Here is the teacher code interviewed by researchers:

Table 3 Interview Code for Physics Teachers

Code	Field of Study of Educators	Graduates
RJ	Master of Physics	Bachelor
N	Master of Physics	Bachelor
R	Master of Physics	Bachelor

3. Results and Discussion

The following are detailed research results related to the perception of students and physics teachers on STEM-based teaching materials.

Table 4 Results of Questioner Students for Physics Teaching Materials

No	Statement	%	Category
1	I only use visual learning media	68,39%	Agree
2	I only use audio learning media	60,87%	Agree
3	I utilize audio-visual learning media	77,02%	Strongly agree
4	I use non-electronic books in the learning process	74,78%	Agree
5	I utilize electronic books in the learning process	62,22%	Agree
6	I do not use student worksheets during practicum	72,31%	Less Agree
7	I don't use virtual laboratories in the learning process	67,38%	Less Agree
8	I easily understand the material with textbook teaching materials	62,89%	Agree
9	I easily understand the material with interactive teaching materials	80,16%	Strongly agree
10	I only need learning media in the form of textbooks	52,91%	Agree
11	I don't need interactive learning media	81,17%	Disagree
12	The teacher delivers science material with practicum	76,35%	Strongly agree
13	The teacher delivers science material with stimulation or animation	72,31%	Agree
14	The teacher delivered science material with demonstrations	66,59%	Agree
15	My place of school provides WIFI	72,87%	Agree
16	WIFI available at school can be accessed by students	51,68%	Agree
17	I use the school's WIFI for the learning process	53,59%	Agree
18	I use school WIFI for social media (WhatsApp, Instagram, Twitter, Line, and Youtube)	51,57%	Agree

Revert in table 4 shows students often use audio-visual learning media rather than audio or visual only, students often use non-electronic books rather than electronic books. Students often use lab worksheets rather than virtual laboratories, participants are easier to understand the material with interactive teaching materials than textbooks, students more requires interactive media than stimulation, animation, and demonstration, there is WIFI in the school but WIFI is not fully accessible to students, and students take advantage of school WIFI for learning and social media processes. Based on table 2 can be concluded in the ongoing learning process Students (1) use audiovisual learning media, (2) less use of electronic books, (3) less use of virtual laboratories, (4) easy to understand the material with interactive teaching materials, (5) need interactive media, and (6) WIFI has been used in the learning process.

Revert table 4 shows reinforced the FGD by students, along with discussion opinions in each discussion group. There are a number of questions asked by the moderator namely the researcher, following the results of the discussion between researchers and students:

Table 5 Results in Focus of Student Discussion Groups

No	Outcome Type	LI	MI	HI
1	Teaching materials used	Printed book	Printed books and materials from the internet	Printed book
2	The advantages of teaching materials used	Complete, reality, formulas and tests for each chapter	Complete, reality, formulas and tests for each chapter	Complete, reality, formulas and tests for each chapter
3	Weaknesses of teaching materials used	Bored, Difficult and Less Attractive	Difficult	Less complete
4	Expected teaching materials	Have visual examples and practice	Details and colors vary	Teaching Materials that can be displayed on the LCD
5	Expected teaching material content	Complete understanding	Understanding, explanation, formulas, examples	Concept maps and summaries
6	Teaching materials lead to creative	No need	Need	Need
7	Learning video component	Using everyday language	Complete material	Educative and easy to understand
8	Reasons for the integration of teaching materials with technology	Easy to access	Book teaching materials are not yet complete	Add insight into knowledge
9	Reasons Interactive books are applied to learning	Easy search for pages	More than one book source	Easy to understand

No	Outcome Type	LI	MI	HI
10	Components in interactive books	Pictures, audio, and animation	Animation, videos, internet links, summaries	Subject matter
11	Hardest physics material	Stationary Wave, Temperature and Heat	Stationary Wave and Newton's Law	Newton's Law
12	The way educators explain the hardest material physics	Lecture	Lecture	percentage
13	Solution to understanding the hardest material in physics	provide examples (practices, explanations, and questions)	Conducive classroom environment	taught in detail and slowly
14	The reason for the importance of integrating material with Science, Technology, Engineering, and Mathematics	adding insight	understanding a lot of material at one time	can integrate subjects with each other

Revert table 4 and table 5 is strengthened by Teacher's interview. The teacher uses powerpoint media, practicum tools, printed books and sometimes makes creativity with simple tools (RJ), LCD, internet (N) and e-book (R). But the media used today does not represent learning because it must integrate several media in one learning (RJ and R), and sometimes the material cannot be represented by existing media, the hope is that there is animation or media that can represent material in depth (N). Some media in the form of teaching materials commonly used by teachers have printed books from schools, books in libraries, internet (RJ), articles, books from schools, e-books (R) and materials from the internet (N). Each teaching material has advantages and weakness. Based on interviews with teachers the excellence of teaching materials that are used systematically, but not entirely in one book (RJ, N), using e-books on LCD aids The teacher easily controls the learning situation (R). The weakness of the teaching materials used by the teacher is lack of abdomen (RJ), material is incomplete, language is difficult to understand by students (N), one book that is used does not represent the material as a whole so the time is less efficient and the teacher does not have a special e-book that discusses the material detailed and in-depth (R).

Various advantages and weaknesses of teaching materials that have been described, teachers need teaching materials that are easy, simple, time-efficient, easy to understand Students (RJ) and special teaching materials that discuss the material in depth (RN). The content that must exist in teaching materials includes core competencies, basic competencies, goals, material coverage, and indicators (RJ), video, reality, games, concepts (N), each material is explained in detail in each sub-chapter to the smallest point and gives an example to each sub-chapter described (R). In addition to the content that needs to be considered in teaching materials is to guide creative students in accordance with 21st-century learning (RJN) and can apply the material in daily life (R).

Teaching and learning components in the form of video and animation include core competencies, basic competencies, Indicators, instructional materials and daily applications (RJ), core competencies, basic competencies, Indicators, objectives, concepts of material must be clear (N), cartoon images, abducting and using Student language so it's easier to understand (R). It is necessary to integrate teaching materials with technology because it is easy to access anywhere (RJ and N), simplifies the learning process and is more efficient (R). Teaching materials also need to be interactive because the subject matter will be easily understood (RJ, N, and R). One of them is interactive teaching materials, namely interactive e-books that need to be implemented because there are no teaching materials that discuss the material in detail and are packaged in such a way (RJ), but to be applied in a compulsory way to look at the situation and conditions (N). The components must be in the e-book include videos, practice questions, and questions. Between questions and answers are given space so that students work first and then the discussion is displayed. It also needs to be interactive and online-based so as to reduce the workload of teachers and anticipate during holidays (R).

Some of the elusive material for students includes rotational dynamics, particle dynamics, dynamic electricity (RJ), particle dynamics, dynamic electricity, electromagnetic waves (N), dynamic electricity and right-hand rules (R). During this time the teacher teaches difficult material by integrating several instructional materials and the internet (RJ), a simple practicum but has not represented an indicator because of the limitations of practicum tools (N), the teacher only teaches material that is understood by material that is not too well understood but there are indicators not taught to student (R). The teacher's solution in teaching difficult material by way of practice, showing animation, stimulation, discussion of questions (RJ and N), training for teachers so that the teacher can make interesting media to be presented in learning (R).

In the learning process, the teacher has not fully implemented the learning of Science, Technology, Engineering, and Mathematics (STEM) RJ and N have implemented STEM, not all the material has been applied because of the extensive skills needed for the Teacher to apply STEM and R has linked the material with STEM because of the interrelationship this will add to students' insight. However, even though the Teacher has applied part or all of the learning to the lesson plans, RJ, R, and N have not implemented STEM. This shows the lack of readiness of the teacher between the lesson plans made with the application in learning.

Based on the results of previous research, one of the things that need to be considered in conducting learning is teaching materials, teaching materials that will support better learning and can produce competent graduates [26–28]. Quality teaching materials will get qualified graduates because the teaching material is the main source of acquiring knowledge. Teaching materials have been developed and applied to previous research to improve the quality of graduates [23], [29–33]. In this study analyzing future physics teaching materials based on STEM in the national curriculum. Based on interviews, observations and focus group discussions on future teaching materials based on STEM in the national curriculum include (1) teaching materials in lesson plans, interactive books, videos, animation, stimulation and practicum, during this time the teacher's teaching materials have not been integrated with STEM, this is shown by the teacher's unpreparedness in making lesson plans, the lesson plans made by the teacher are not integrated with STEM but learning is sometimes integrated. (2) components of interactive book teaching materials include core competencies, basic competencies, indicators, objectives, concept maps, pictures, videos, animations, subject matter explained in detail in each chapter, detailed formula discussion, internet links, summaries, and questions. (3) video components include (core competencies, basic competencies, objectives, indicators, abdet, using everyday language,

complete material and easy to understand), (4) physics material expected to need interactive books including stationary waves, temperature, and heat, law Newton, dynamic static and electricity. All teaching materials are expected to be based on e-learning or mobile learning.

4. Conclusions

Based on the results of questionnaires, discussions, and interviews that the teacher has not made and applied teaching materials based on Science, Technology, Engineering, and Mathematics (STEM) in the national curriculum. To support STEM learning in the national curriculum required teaching materials in the form of lesson plans, interactive books, videos, animation stimulation, and practicum. Components of interactive book teaching materials including core competencies, basic competencies, indicators, goals, concept maps, pictures, videos, animations, subject matter explained in detail in each chapter, detailed formula discussion, internet links, summaries, and questions. The video components include core competencies, basic competencies, goals, indicators, abducting, using everyday language, complete material and easy to understand. The physics material expected in STEM learning includes stationary waves, temperature and heat, Newton's laws, dynamic electricity, and static electricity. All teaching materials are expected to be based on e-learning or mobile learning. So in the future, there needs to be the development of STEM-based teaching materials to support 2013 learning that is designed to the maximum.

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