Teachers' perceptions of 3D technology-integrated student worksheet on magnetic field material: A preliminary research on augmented reality in STEM learning

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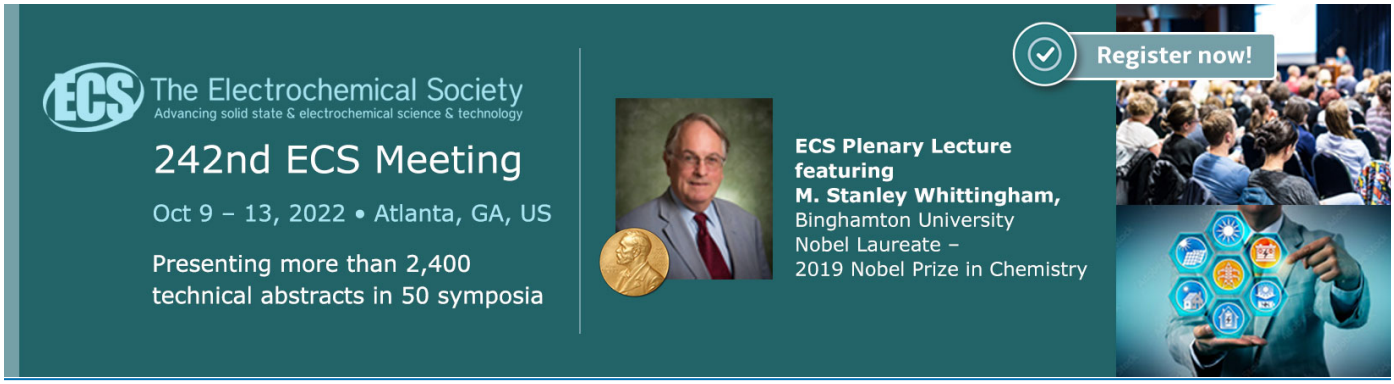

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Teachers' perceptions of 3D technology-integrated student worksheet on magnetic field material: A preliminary research on augmented reality in STEM learning

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Abstract. The change in civilization aimed at the industrial revolution 4.0 and the era of society 5.0 is a discourse in the world of education. Learning activities are a major part of education at schools, thus, they require learning devices and teaching materials updates. The development of learning resources, such as electronic student worksheets, can be used as a solution to obtain 21st-century skills. This study was aimed to analyze teacher and students' perceptions about augmented reality-assisted worksheets with STEM approach in physics learning. The research was conducted at high schools in Lampung Province involving 139 twelfth-grade students and 16 physics teachers. The method used was the mixed-method. The research instruments used were questionnaires and telephone interviews. The results showed that teachers have not fully used augmented reality-based teaching materials STEM approach. The types of teaching materials needed by students and teachers are interactive teaching materials integrated with STEM. STEM allows students to deepen their abilities in the fields of science, technology, engineering, and mathematics, so it is necessary to develop augmented reality-assisted worksheets with STEM approach to face the challenges of the industrial revolution 4.0 and meet the competency standards in the 21st-century, namely the critical-thinking ability on magnetic field material.
Keywords: augmented reality, critical thinking, e-student worksheet, PBL, STEM.

1. Introduction

Education is currently being developed to face the industrial revolution 4.0 and the era of society 5.0 [1]. Most recently, the world is facing the COVID-19 Pandemic which has changed aspects of human life, especially in the world of education [2]. Mastery of technology is used as an alternative learning solution where interaction between teachers and fellow students can still be done without having to meet directly [3].

The changes in civilization require people to master 21st-century skills [4]. Education should have a strategic role to prepare young people who meet the qualifications according to the challenges of the 21st-century, namely (1) problem-solving and critical thinking; (2) communication and collaboration; and (3) creative invention [5,6]. However, the ability of Indonesian students is relatively low, especially in the field of science. This can be analyzed from the results of the PISA (Program for International Student Assessment) in 2018 which shows that the scientific ability of Indonesian students was 396 [7]. The results of the 2015 TIMSS study put Indonesia in 45th place out of 50 participating countries [8].

One of the problems faced by science learning that does not involved students to be interested in learning aspects of Science, Technology, Engineering, and Mathematics (STEM) [9-12]. In the future, STEM will be able to bridge the gap between education and the workplace required by the 21st-century [13,14]. Therefore, teachers' innovation is needed in the STEM context, thereby fostering student interest which will have an impact on the growth of 21st-century skills [15].

In the context of STEM education, technology plays an important role [16]. The rapid changes in the world of education today require students to have 21st-century skills, one of which is the ability to think critically [17,18]. The 21st-century learning focuses on students' abilities and study skills [19,20]. Efforts that can be made are to integrate STEM into the learning process [21,22]. However, in Indonesia, STEM still has not received special attention, especially by teachers in terms of teaching materials [23,24].

Teaching materials are a source of knowledge for students [25,26]. By integrating teaching materials with STEM, it is expected that student learning motivation will increase [27,28]. The use of stem integrated teaching materials also improves students' thinking skills [29,30]. Teaching materials require input to convey information through text, graphics, animation, simulation, and video [31]. 3D multimedia applications are designed to show certain results [32,33]. Types of teaching materials are divided into (1) books, handouts, worksheets, and teaching materials and (2) newspapers, clippings, news, and films [34,35].

The development of an e-student worksheet can be used as a solution to achieve 21st-century skills [36]. In physics learning, there is a magnetic field discussion which is one abstract concept. Learning that utilizes augmented reality can help students because it presents the material in 3D format [37,38]. The 21st-century skills must be taught to students using appropriate teaching material. The development of an augmented reality-assisted e-students worksheet with the STEM approach can be an alternative instrument. Previous research has examined the augmented reality-based STEM approach [39,40]. This research was conducted to analyze the perspective and the needs of students and teachers about STEM integrated e-student worksheet so that the types of teaching materials needed to face the 21st-century can be determined.

2. Research Method

2.1 Research Method

This research employed a mixed-method with a sequential explanatory strategy. The research had been conducted at several high schools in Lampung province. The research subjects were 139 twelfth-grade students and 16 high school physics teachers in Lampung Province.

2.2 Data Collecting Technique

The data had been collected using questionnaires and interviews. The questionnaires and interviews were analyzed quantitatively and described qualitatively. The interpretation of the interview data can be seen in Table 1.

Table 1. Interpretation of Students' Perceptions toward 3D Animation-Based Teaching Material with STEM Approach

Interval (%)	Beneficial	Not Beneficial
$75 < x \leq 100$	Strongly Agree	Strongly Disagree
$50 < x \leq 75$	Agree	Disagree
$25 < x \leq 50$	Disagree	Agree
$0 < x \leq 25$	Strongly Disagree	Strongly Agree

Sixteen physics teachers were interviewed to analyze their regularly used teaching materials. The following are the teacher interview code:

Table 2. High School Teacher Interview Code

Code	Gender	Subject	Education	Teaching Experience
LR	Female	Physics	S-2	21 years
Y	Female	Physics	S-1	15 years
N	Female	Physics	S-1	22 years
SK	Female	Physics	S-1	14 years
SU	Male	Physics	S-1	19 years
MM	Male	Physics	S-1	15 years
HAR	Male	Physics	S-1	16 years
HN	Female	Physics	S-2	21 years
VQ	Female	Physics	S-1	16 years
RH	Male	Physics	S-2	23 years
US	Male	Physics	S1	11 years
PR	Male	Physics	S-1	14 years
YU	Female	Physics	S-1	15 years
CA	Male	Physics	S-1	14 years
HE	Female	Physics	S-1	15 years
J	Female	Physics	S-1	16 years

3. Result and Discussion

3.Result

The detailed research results regarding the perceptions of physics teachers and students on interactive teaching materials integrated with STEM can be seen in Table 3.

Table 3. Students' Questionnaire Responses about Interactive Teaching Materials

No.	Questions	%	Category
1	I only use visual learning media	65%	Agree
2	I only use audio learning media	63%	Agree
3	I use audiovisual learning media	80%	Strongly Agree
4	I use non-electronic worksheets	73%	Agree
5	I use electronic worksheets	34%	Agree
6	I don't use virtual laboratories	49%	Disagree
7	I can easily understand learning with student worksheet	65%	Agree
8	I easily understand lessons with interactive media	83%	Strongly Agree
9	I need printed student worksheet media	69%	Disagree
10	I don't need learning media	91%	Strongly disagree
11	Teachers deliver material with animation	60%	Agree
12	Teachers deliver material with Augmented Reality (AR)	33%	Disagree
13	The teachers deliver integrated STEM material	64%	Disagree
14	I use electronic media	65%	Agree
15	My school has adequate laboratory facilities and WIFi	49%	Agree

Table 3 shows that students often use audio-visual learning media and printed student worksheets rather than electronic worksheets. They can better understand the subject matter by using electronic worksheets assisted by 3D animation rather than printed worksheets, students need interactive learning media such as animation, demonstrations, and stimulation. The teachers rarely applied the

Augmented Reality-assisted STEM approach. The WIFI facilities are available that can facilitate the learning process and access social media at school. Based on table 3 it can be concluded that in the student learning process, (1) the audiovisual learning media were often used, (2) electronic student worksheets had been used, (3) students could easily understand the technology-integrated teaching material, (4) students desperately needed concrete learning materials, and (5) students used mobile learning in the learning process with available WIFI facilities. Teacher questionnaire responses can be seen in Table 4.

Table 4. Teacher Questionnaire Responses on Electronic Worksheets

No	Questions	Yes (%)	No (%)	Total	
				Yes	No
1	Do you use media in learning physics?	100%	0%	16	0
2	Do you use teaching materials in learning physics?	100%	0%	16	0
3	Do you use STEM (Science, Technology, Engineering, and Mathematics) integrated teaching materials?	81,25%	18,75%	13	3
4	Do the teaching materials that you use to guide students in improving critical thinking skills in learning physics?	68,75%	31,25%	11	5
5	Do you use the STEM approach in the physics learning process?	93,75%	6,25%	15	1
6	Do you use the Augmented Reality student worksheet?	31,25%	68,75%	5	11
7	Do you need an electronic student worksheet?	100%	0%	16	0
8	Should worksheets be accessible anywhere and accessed via mobile learning?	100%	0%	16	0
9	Do you need a STEM approach integrated Augmented Reality-assisted electronic student worksheet?	100%	0%	16	0

Based on table 4, the teachers have used learning media in the physics learning process although it has not fully integrated with the STEM approach. The teachers needed an electronic worksheet assisted by augmented reality and teachers needed worksheets that can be accessed anywhere via mobile learning. Teachers have used learning media in the form of printed worksheets and simple practical tools (LR, SK, Y, SK, HE), the internet (HAR, YU, VQ, AS), and made simple practicum tools as learning media (MM, YU, SU).

The learning media used today are not fully representative because they have to adjust several media in one lesson. Few teachers have applied AR technology (LR, SK, VQ, YU, SU). Sometimes, the material cannot be represented by existing media because it was too abstract (HAR, YU, VQ, AS, SK, HE). They hope an electronic worksheet that can represent material in depth can be made (VQ, AS, SK, HE).

The worksheets commonly used were printed student worksheets (SK, Y, SK, HE, RH, CA). The weakness of the worksheets used by the teacher is that the teaching materials cannot compete with current developments (HE, RH, CA). The worksheet cannot support scientific procedures with difficult to understand language (AS, SK, HE). The worksheets used do not represent the entire work procedure so learning is less effective and teachers do not have e-worksheet which discusses the material in detail (HAR, YU, MM, VQ, USA).

The worksheets needed by the teacher are those that have components relevant to the learning objectives (RH, YU, and N) and procedures. Work steps must be directed covering material, core competencies, basic competencies, and indicators (HAR, YU, MM). The material must be interactive, such as video, animation, reality, and fun design (CA, VQ, AS, SK, HE). Each process is explained in detail and clearly so that students can understand the material and apply it in scientific work procedures (HAR, YU, VQ). Magnetic fields, especially in the process of magnets producing electricity, is considered difficult (AS, SK, HE). The teachers had difficulty in teaching material and

guiding magnetic field experiments (CA, Y, MM). The material is still difficult to convey with practicum, provides animation, questions, and interactive discussions (PR, HAR, YU, VQ, LR).

Therefore, augmented reality needs to be given to students to optimize the benefits of ICT in the physics learning process [41,42]. Also, teachers have not fully integrated material with Science, Technology, Engineering, and Mathematics (STEM). CA, YU and HE have integrated some materials assisted with augmented reality with a STEM approach. Special skills are required to integrate STEM augmented reality into learning and require teaching materials such as electronic worksheets to achieve learning objectives.

The following is the STEM integration design in teaching materials according to the results of observations and interviews:

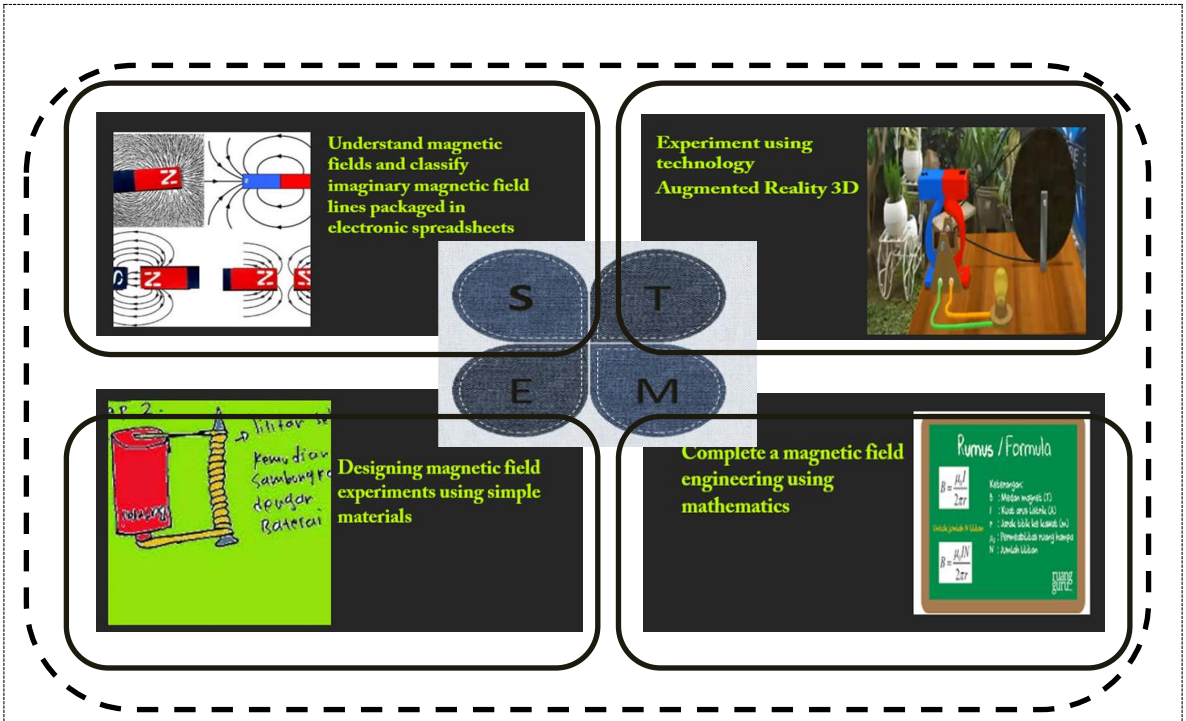

Figure 1. STEM Integration Design in Teaching Materials

Based on research results, student worksheets should get special attention in the learning process in terms of quality because it is one of the sources for gaining knowledge. Teaching materials have been developed and applied to improve the quality of graduates [43,44]. Therefore, it is important to analyze the types of teaching materials needed by students and teachers so that they can compete globally.

Based on the results of the analysis, the types of teaching materials needed by students and teachers are electronic worksheets assisted by 3D animation using augmented reality and integrated with the STEM approach. STEM allows students to explore their abilities in science, technology, engineering, and mathematics. The components that need to be included are (1) electronic worksheet components, including pictures, videos, animations, learning material, and learning procedures, (2) worksheet components which include core competencies, basic competencies, indicators, objectives, reality, and definitions. Each material, discussion of formulas and summaries, and scientific procedures must be explained in detail; (3) video components should include core competencies, basic competencies, objectives, indicators, up-to-date, easy to understand language, complete, and easy to understand the material.

4. Conclusion

Based on the results of research and discussion, it can be concluded that teachers have not fully integrated learning materials with Science, Technology, Engineering, and Mathematics (STEM). Thus, it is necessary to develop electronic student worksheets integrated with STEM that are capable to facilitate the learning process, especially on difficult to understand the material. The teaching materials expected by students and teachers are (1) electronic worksheet components that include pictures, videos, animations, procedures, and summaries; (2) relevant to core competencies, basic competencies, indicators, and objectives; (3) use easy to understand language, and (4) the material discussed should be focused on the magnetic field. It is expected for further research to improve teaching materials to contain skills needed in the industrial revolution era 4.0 so that students can compete globally.

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