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Case Analysis of Learning Physics in Improving 21st-Century Skills

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ABSTRACT

The government makes various policies to deal with changes in the 21st century, one of which is by implementing the 2013 curriculum. The curriculum that was applied focused on student center approach. Further research needs to be done to determine whether physics learning in SMA/MA follows the 2013 Curriculum and can acquire students with 21st-century skills. This study aims to determine the current quality of Physics learning, problems that occur in Physics learning, and solutions to solve the problems that occur in Physics learning. The research was conducted using a qualitative descriptive method. The research instrument used was a questionnaire google form given to 20 physics teachers and 50 students in senior high school in West Sumatera. In order to obtain further detailed information, three teachers were interviewed. Based on the questionnaire and the results of interviews, it was concluded that the learning of Physics is following the demands of the 2013 Curriculum and can improve the 21st-century skills of students, but it could be more optimal. Therefore, to find a solution to this problem, the researcher recommends developing a project-based and STEM-integrated textbook.

INTRODUCTION

The rapid development of science and technology is one of the characteristics of life in the 21st century. Various aspects are starting to be replaced rapidly by mechanical technology and artificial intelligence or Artificial Intelligence (AI). Industries based on data, information, knowledge, and expertise have a greater impact on the world economy and everyday life than traditional factory-based industries (Trilling & Fadel, 2009). This change places a lot of skill demands on the workforce, such as being skilled in using technology, being able to find solutions to a problem quickly, being able to work in teams, and being able to work in various fields or multidisciplinary fields (Griffin, Mc Gaw, & Care, 2012). It shows that almost all human activities can be controlled and controlled by tools resulting from the development of science and technology (Rante, Sudarto, & Ihsan, 2013). Every society in this era must be able to deal with these changes so that they can continue their lives.

These changing times impact every area of life, including education. The rapid development of science and technology must be balanced with an increase in the quality of learning, especially in Physics, so this is one of the challenges that must be faced in education (Pahrudin, Irwandani, Triyana, Oktarisa, & Anwar, 2019). The effort made by the government to deal with changes in the 21st century in the field of education is to revise the 2006 to 2013 curriculum. The teacher center view has been changed to a student center by the 2013 curriculum so that students can have various skills needed in the 21st century, such as competing, collaborating, being creative, and being innovative. Educators must provide materials, activities, and resources that assist students in developing 21st-century skills in formal and non-formal environments (LaForce et al., 2017).

Twenty-one-century skills comprise a broad range of skills and abilities necessary for success in technology. They support lifelong learning that enables students to adapt and become more responsive as the world around them changes. The importance of mastering 21st-century skills is because, at this time, students are required to develop life skills and soft skills, including critical thinking skills, creative thinking, communication, and collaboration, or what are known as 4C skills. These skills must be provided to students in addition to mastery of learning materials and concepts at school. Skills of 4C cause education to become increasingly important to ensure students have these skills. Table 1 is a comparison of the 21st-century skills framework proposed by several organizations, namely the Partnership for 21st Century Skills (P21), the Organization for Economic Cooperation and Development (OECD), and the Assessment and Teaching of 21st-Century Skills (ATC 21 S). See more clearly related to 21st-century skills, and the P21 framework is broken down into three sets of skills and twelve components arranged as in Table 2 (Chu, Reynolds, Tavares, Notari, & Lee, 2016).

Table 1. Comparison of 21st Century Skills Frameworks

P21 (Skill group)	OECD (Dimensions)	ATC21S (Category)
Learning and innovation skills	*Communication*	*Ways of thinking* (*creativity and innovation; critical thinking, problem-solving, decision making; learning to learn, metacognition*) *Ways of working* (*communication; collaboration/teamwork*)
Information, media, and technology skills	*Information*	*Tools for working* (*Information literacy; ICT literacy*)
Life and career skills	*Ethics and social impact*	*Living in the world* (*Citizenship; life and career; personal and social responsibility*)

Table 2. Capabilities for Each Group of 21st-Century Skills

Learning and innovation skills	*Digital literacy skills*	*Life and career skills*
Core subjects	*Information literacy*	*Flexibility and adaptability*
Critical thinking and problem solving	*Media literacy*	*Initiative and self-direction*
Communication and collaboration	*Information and communication technology literacy*	*Social and cross-cultural interaction*

Creativity and innovation	*Productivity and accountability* *Leadership and responsibility*

Education in the 2013 Curriculum must also be based on a scientific approach. Models that can support this approach include Project-Based Learning (PjBL), Problem-Based Learning (PBL), or Discovery Learning (Afriana, Permanasari, &Fitriani, 2016). The models suggested in the curriculum can be selected and adapted to the characteristics of the subject matter. For example, suppose the material being studied can be studied from various disciplines and requires many different academic skills such as reading, writing, mathematics, and building conceptual understanding by assimilating different subjects. The teacher can apply a project-based learning model (Capcaro, Capcaro, & Morgan, 2013).

Multidisciplinary knowledge and skills are important for students to face the challenges of the 21st century. Indonesia needs to prepare a reliable generation in various disciplines such as Science, Technology, Engineering, and Mathematics (STEM) to face global competition (Subekti, Taufiq, Susilo, Ibrohim, &Suwono, 2018). STEM education aims to equip students with scientific and technological literacy so that if they are in society, they can face problems in everyday life (Bybee, 2013).

Gao, Li, Shen, & Sun (2020) also outline the learning objectives of implementing STEM based on knowledge, attitudes, and skills. The basic goal of STEM education from the knowledge side is to help students develop content knowledge for one or more specific disciplines within STEM. For example, a common approach in STEM education is using engineering design to help students develop math and science knowledge. Furthermore, the goal of STEM education in terms of skills is to help students develop skills that extend beyond one discipline. Based on this perspective, programs focusing on STEM integration have used learning tasks placed in the context of complex situations and require students to apply knowledge from multiple disciplines. In this way, the importance of each discipline is treated on the same level (helps understand the situation), and the amount of knowledge for each discipline depends on the nature of the problem or learning situation. In contrast, the attitude domain includes student interest, engagement, attitude, and motivation for STEM content and practical aspirations in STEM professions.

STEM has become a term to describe the necessary skills for workers in the 21st-century global economy. Khine&Areepattamannil (2019) state that students who are educated in STEM subjects tend to show certain characteristics, namely critical thinking, creativity, innovation, communication, collaboration, and entrepreneurship. In addition, through STEM education, students are expected to have adaptation skills, complex communication and social skills, non-routine problem-solving, self-management and self-development, and systems thinking (Bybee, 2013).

STEM can be integrated into other learning models, such as Project-Based Learning (Capcaro, Capcaro, & Morgan, 2013). The PjBL learning model emphasizes contextual learning through complex activities such as giving freedom to students to explore planning learning activities, carrying out projects collaboratively, and ultimately producing a product. One characteristic of project-based learning is that students make decisions about a framework. There are problems or challenges posed to students; students design processes to determine solutions to problems or challenges posed; students are collaboratively responsible for accessing and managing information to solve problems; the evaluation process is carried out continuously, and students periodically reflect on activities that have been carried out,

the final product of learning activities will be evaluated qualitatively. The learning situation tolerates errors and changes (Kemdikbud, 2014).

STEM integration into the PjBL model is now known as the STEM-PjBL model. STEM-PjBL learning is project-based learning that integrates STEM fields into it. Science requires mathematics as a tool for processing data, while technology and engineering are science applications. Some benefits of the STEM-PjBL approach are that it can make students able to solve problems better, be innovative and independent, think logically, and have technological literacy (Morrison in Stohlamnn, Moore, &Roehrig, 2012). In addition, STEM-PjBL can also grow students to think critically, creatively, and analytically and improve higher-order thinking skills (Capcaro, Capcaro, & Morgan, 2013; Netwong, 2018; Sahin, 2015). STEM-PjBL provides students with experience in solving real problems with practical activities to increase effectiveness and meaningful learning and support future careers (Tseng, Chang, Lou, & Chen, 2013). So, applying the PjBL model and integrating STEM into Physics learning can produce students who can think logically, and creatively, solve problems, are skilled in using technology, adapt to change, and have scientific literacy.

Applying approaches and models in current learning, especially STEM-PjBL, aims to enable students to acquire various skills needed in the 21st century. It shows that the 2013 Curriculum must carry out learning Physics to produce students with 21st-century skills. Therefore, it is necessary to research whether the teaching of Physics in SMA/MA is by the 2013 Curriculum and can produce students with 21st-century skills. This research aims to discover the quality of current Physics learning, the problems that occur in Physics learning, and solutions to overcome problems that occur in Physics learning.

METHODS

The research method used in this research is descriptive qualitative. The population in this study were all Physics teachers and SMA/MA students in West Sumatra Province. Furthermore, using a simple random sampling technique, namely how to randomly take members of the population without regard to strata in the population, the research sample consisted of 20 Physics teachers and 50 SMA/MA students in West Sumatra Province. Data was collected using a Google form questionnaire from SMA/MA Physics teachers. Based on the questionnaire, several analyses were carried out, such as teacher performance in teaching, completeness of facilities and infrastructure, graduation standards, models and methods used in learning, and textbooks. Questionnaires were also given to students to find out the characteristics of students such as interests, motivation, learning styles, attitudes, knowledge, and students' skills in learning Physics. Interviews were conducted with three Physics teachers to support and complete the questionnaire result data; the data that has been obtained was then analyzed using a Likert scale. The Likert scale measures attitudes, opinions, and perceptions of a person or group about social phenomena. The categories of the analysis results are obtained by calculating the scores obtained from each respondent using the following equation.

$$Sk = \frac{\sum Xi}{\sum \max} x100\%$$

Sk is the score obtained, Xi is the score for each respondent, and Xmax is the maximum score from the questionnaire for each indicator. The data obtained from teacher and student questionnaires were interpreted based on categories, as seen in Table 3 (Riduwan, 2010).

Table 3. Category Analysis of Teachers and Analysis of Student Characteristics

Percentage	Category
81-100	Very High
61-80	High
41-60	Enough
21-40	Low
0-20	Very low

RESULTS AND DISCUSSION

Results

Giving questionnaires to teachers and students aims to find out what cases or problems occur in high school physics learning in West Sumatra Province. Problems in learning Physics can be analyzed through teacher performance in the classroom, from the teacher preparation stage before learning to the stage of evaluating the learning being carried out. The results of the physics teacher's performance analysis can be seen in Figure 1.

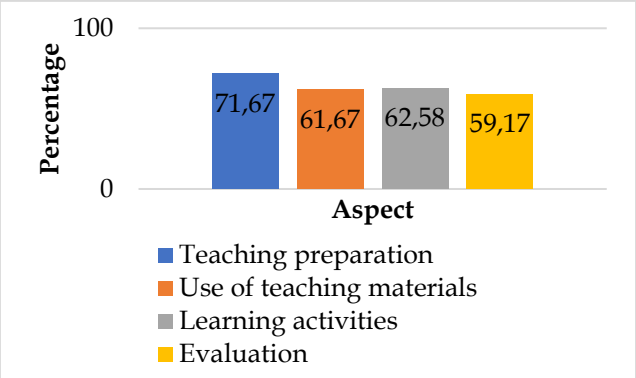

Fig. 1. Performance Analysis of SMA/MA Physics Teachers in West Sumatra Province

Figure 1 shows that the Physics teacher has made preparations before carrying out learning with the percentage obtained is 71.67% and is in the high category. Before starting the lesson, the teacher has prepared learning tools and several learning resources that students can use for each meeting. Based on the interview activities, the three teachers also stated that they always prepare to learn tools such as lesson plans and worksheets. However, in preparing these learning tools, teachers still need a long time to prepare and help determine the right learning media for each Physics material. Based on interview results, teachers usually only use media in the form of PPT and learning resources in the form of books from the Ministry of Education and Culture. The aspect of using teaching materials is 61.67% in the high category. Teachers have used teaching materials in learning Physics. However, only some teachers develop their teaching materials, so they still need to contain a learning model. It is supported by the interviews where the three teachers stated that the teaching materials used were developed by the MGMP and sometimes taken from the internet.

The learning activities carried out by the teacher in the classroom are in the high category, with a percentage of 62.58%. Teachers have used laboratory tools in learning Physics. However, the learning carried out by teachers still needs to follow the 2013 curriculum standards fully. Only 65.00% of teachers have implemented the student center approach. Most teachers have implemented the model suggested by the 2013 Curriculum. However, teachers use only one model, such as Discovery Learning or PBL. Teachers stated

that using models in physics lessons was difficult because the time to complete solid physics materials needed to be improved.

In addition, teachers have also guided students to improve 21st-century skills, but the results obtained have yet to be maximized. One of the ways that teachers can improve their 21st-century skills is to apply the PjBL model in learning. SMA/MA Physics Teachers in West Sumatra Province have implemented project-based learning. However, several stages still need to be carried out, such as guiding students to find an appropriate model to solve problems and connecting disciplines still need to test this model. The problems studied are also outside the form of real-life problems students face. Based on the interviews conducted, the teacher stated that the projects carried out by students were usually only conceptual projects, not projects that aimed to solve problems that existed in everyday life.

The teacher's ability to carry out evaluations is in a good category, with a percentage of 59.17%. It shows that most teachers still need help to evaluate student learning outcomes. Teachers also need help in carrying out assessments of students' 21st-century skills.

The subsequent analysis is the aspect of facilities and infrastructure owned by the school. The facilities and infrastructure reviewed in this study are focused on the laboratory's feasibility and the laboratory equipment's completeness. Figure 2 shows that the percentage of laboratory feasibility and completeness of laboratory equipment is in the high category. Teachers can use the laboratory to support physics learning, such as practicum-based and project-based learning.

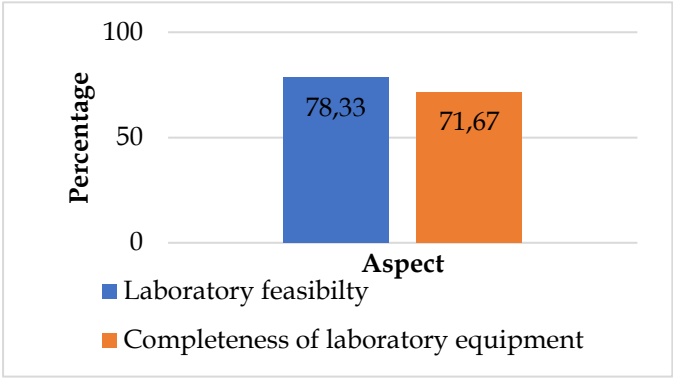

Fig. 2. Analysis of Completeness of Facilities and Infrastructure

To determine students' competence, an analysis of graduate standards is carried out. Analysis was carried out on four aspects: spiritual attitudes, social attitudes, knowledge, and skills. The results of the analysis for each aspect are shown in Figure 3.

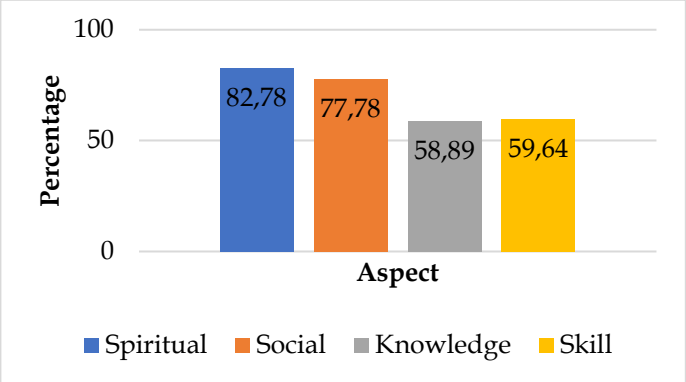

Fig. 3. Analysis of Student Graduation Standards

Figure 3 shows that the spiritual attitude aspect of students is in the very high category, and the social attitude aspect is in the high category. These two aspects have a higher percentage than the knowledge and skill aspects. In learning Physics, students can find examples of applying Physics material in everyday life. However, students still need help to express facts and build physics concepts in the learning process. Students still need help understanding Physics principles and solving complex Physics problems.

On the skill aspect, several indicators refer to 21st-century skills. These skills include using technology, gathering information, using the media, critical thinking skills, creativity, collaboration, and communication. Based on the data obtained, students' ability to use technology, seek information from various sources, communicate in front of the class, and collaborate in group activities is already in the high category. However, students' ability to think critically and creatively and create media still needs to be improved. Based on the results of the interviews, information was obtained that even though students were able to collaborate well, there were still some students who tended to like working alone.

Furthermore, an analysis of the models and learning methods teachers use in learning is also carried out. The results obtained are shown in Table 4.

Table 4. Analysis of Learning Models and Methods Used in Learning

Indicator	Percentage
The model used is based on real-world contexts	55.83
The model used is based on the experience of students	55.83
The model used is project-based	55.83
The teacher uses the lecture method	85.00
The teacher uses the discussion method	71.67
The teacher uses the practical method	68.33

Based on the data in Table 4, high school/MA Physics teachers in West Sumatra Province are more likely to use the lecture method in explaining Physics material. Discussions were held to solve questions and discuss theoretical material. Most teachers have also carried out practicum to support the theory being studied. However, the problems that arise come from the model used. Teachers have not used models based on real-world contexts and projects, so students must be properly trained to solve physics problems. The models and methods teachers use have also been unable to maximize 21st-century skills.

The final analysis was carried out on the use of textbooks. Textbooks are one of the important components that teachers and students must own. The results of the analysis of the textbooks used are shown in Table 5.

Table 5. Analysis of the Use of Textbooks

Indicator	Percentage
The content in the textbook is by the 2013 Curriculum	97.50
Textbooks only contain material and physics questions	95.83
The textbook contains social issues that are relevant to Physics material	36.67
Integrated teaching materials of science, technology, engineering, and mathematics	29.17

The use of textbooks by high school physics teachers in West Sumatra Province is very high, with a percentage of 97.50%. Based on the results of the interviews, it was found that the textbooks the teacher used were already available in the market, such as the Physics book published by Erlangga and the Physics independent book. The Physics material contained in the textbook is from the 2013 Curriculum. However, this textbook only contains Physics

materials and questions. Teachers' textbooks do not contain the latest social issues and must be integrated with various disciplines such as Science, Technology, Engineering, and Mathematics (STEM). Therefore, the textbooks used have not been able to help students improve 21st-century skills, have not been able to help students solve physics problems, and have yet to be able to facilitate students to learn independently.

This study also gave questionnaires to 50 SMA/MA students in West Sumatra Province. Giving this questionnaire aims to determine the characteristics of students, including interests, motivation of students in studying Physics, preferred learning styles, knowledge, attitudes, and skills. The results of the analysis of the characteristics of students can be seen in Figure 4.

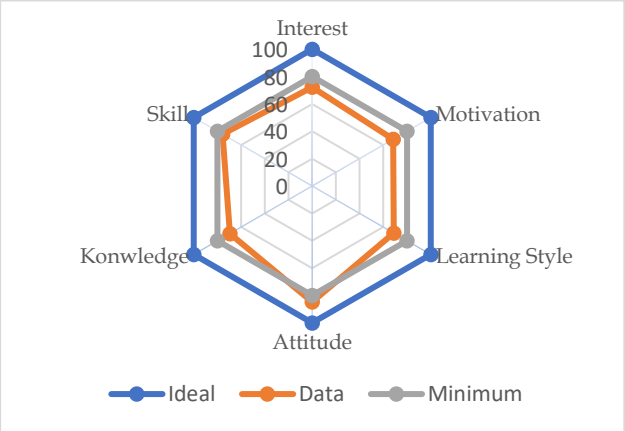

Fig. 4. Analysis of Student Characteristics

The gray line is the minimum score from the very high category, 81.00. Figure 4 shows that students' attitudes are very good, both spiritual and social attitudes. Aspects of skills and knowledge are still in the high category, so these aspects still need to be improved through the learning process. Students have a high interest and motivation in learning Physics. It means that students have feelings of pleasure, interest, and pleasure in receiving learning. However, the interest and motivation of students need to be increased so that the learning obtained is more optimal. Based on the aspect of learning style, it is easier for students to master the concept of Physics by seeing phenomena directly and through project-based learning.

Discussion

Based on the data obtained from teacher questionnaires, student questionnaires, and interviews, several cases or problems can be obtained in implementing physics learning in West Sumatra Province. Teachers need a long time to make learning devices. Media that is suitable for every physics material is also difficult to find. The teaching materials used also differ from the demands of the 2013 Curriculum, where teaching materials are suggested to contain certain models. Teaching materials that contain certain models, such as STEM-PjBL, can improve student learning outcomes (Agung, Suardana, & Rapi, 2021) and problem-solving skills (Purwaningsih et al., 2020). Based on the results of research conducted by Tyas, Harjana, & Wahyuningsih (2020), it was concluded that in improving problem-solving skills in the 21st century, STEM-PjBL-based teaching materials are needed. In addition, STEM-based teaching materials are also needed to support the national curriculum (Widayanti, Abdurrahman, & Suyatna, 2019).

In implementing learning, teachers must still fully implement the student center approach. Teachers tend to use the lecture method because it is faster in teaching solid physics

material. Meanwhile, the project-based learning model is rarely used because no textbooks contain STEM-integrated project-based learning models. It has an impact on the knowledge and skills of students, where aspects of the knowledge and skills of students are still in the good category. This model can support education in the 2013 curriculum (Afriana, Permanasari, & Fitriani, 2016). In addition, applying STEM-PjBL can also increase the effectiveness of learning and make learning more meaningful (Tseng et al., 2013).

Learners' 21st-century knowledge and skills can be enhanced by implementing Science, Technology, Engineering, and Mathematics (STEM)-based learning. STEM-based learning needs to be applied to prepare a reliable generation to face global competition (Subekti, Taufiq, Susilo, Ibrohim, & Suwono, 2018) and has 21st-century skills (Khine & Areepattamannil, 2019). However, in reality, the learning carried out by the teacher still needs to integrate the four disciplines. It is due to the unavailability of textbooks that are integrated with STEM. Therefore, the researcher recommends developing a project-based Physics textbook and integrating STEM into it.

This textbook should be equipped with problems originating from scientific and social issues that exist in real life. The solution to this problem will be solved by connecting interdisciplinary STEM disciplines. It will stimulate students' interest and increase their motivation to study Physics because students will feel that the project they are working on can benefit society. Learning using STEM-PjBL is better at training students to solve problems in everyday life because it can accommodate their ideas and make students more interested in learning (Purwaningsih, Sari, Sari, &Suryadi, 2020). This textbook can guide teachers in implementing STEM-integrated project-based learning so that students' 21st-century skills can improve (Baran, Baran, Karakoyun, & Maskan, 2021). STEM-PjBL can make students able to solve problems better, be innovative and independent, think logically, and have technological literacy (Morrison in Stohlamnn, Moore, & Roehrig, 2012)

CONCLUSION

Based on the results of the analysis that has been carried out, it can be concluded that the teaching of Physics for SMA/MA in West Sumatra Province is currently by the demands of the 2013 Curriculum and can improve students' 21st-century skills, but it is not optimal. It is because teachers still need to implement learning with a student-centric approach fully. Teachers tend to use the lecture method because of their limited time to teach physics material. In addition, teachers still need to implement project-based learning fully. The proposed project design still needs to link between disciplines. It is because no textbooks contain project-based learning models and are integrated with STEM. Therefore, the researcher recommends that it is necessary to develop project-based and integrated STEM textbooks.

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