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Feasibility of Integrating Self-regulated Learning in Physics-STEM Module to Train Creative Thinking Skills

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Abstract.
The teaching materials are the most important components to achieve the learning objectives for teaching and learning. A module is one of the teaching materials that is systematically designed based on curriculum and packaged into learning units, so that it can be used independently by students to achieve learning objectives. Learning objectives are oriented to 21st century skills, one of them being creative thinking skills that can be trained through STEM approach'. On the other hand, implementing STEM learning in Islamic boarding schools requires self-regulated learning. This is intended to foster student independence in order to have optimal learning achievement both academically and tahfidz. Considering that learning in Islamic boarding schools has a solid routine and demands more learning outcomes; therefore, researchers are interested in conducting research on the development of integrating self-regulated learning on physics-STEM modules to train creative thinking skills. This study uses a mixed method with a sequential exploratory design. It is intended to obtain qualitative and quantitative data. Qualitative data is needed to design self-regulated learning on physics-STEM module. Quantitative data is used to determine the validity of the module's feasibility and improvement of creative thinking skills. However, this study only arrived at the feasibility of integrating self-regulated in physics-STEM module, so it emphasizes more on qualitative data. The creative thinking skill instrument was designed based on the 2021 PISA framework. The participants in this study were three lecturers of expert validators. The results showed that the validation of self-regulated learning in physics-STEM module is of very high category.

Keywords: self-regulated learning, physics-STEM module, creative thinking skills

1. INTRODUCTION

One of the 21st century skills according to the Partnership for 21st Century Skills (P21) is creative thinking skills. Creative thinking skills are needed in order to be able to generate new creative ideas. In developing creative thinking skills, it can be done using an integrative approach [1]. The integrative approach is a learning approach that is carried out using more than one discipline, for example the STEM (Science, Technology, Engineering, and Mathematics) approach. Learning with the STEM approach is learning by integrating four disciplines, namely science, technology, engineering, and mathematics. The existence of integration between disciplines in STEM learning indirectly trains problem solving skills in real life and is able to train 21st century skills to face future careers [2]. Several studies such as that conducted by [3–5] showed that STEM learning was able to improve creative thinking skill. STEM learning integrates several disciplines, namely science, technology, engineering, and mathematics, presents content that is related to real life so that it triggers students to combine content across content in solving problems.

On teaching and learning process, one of the important components that support the achievement of learning objectives is teaching materials. The module is one of the teaching materials that is systematically designed with reference to the curriculum and packaged into learning units, so that it can be used independently by students to achieve learning objectives [6, 7], stated that the module is a form of teaching material that is arranged systematically and attractively which includes learning objectives, material content and evaluation that can be used independently. Learning objectives in the 21st century is oriented to 21st century skills, one of them is creative thinking skill that can be trained through STEM learning. The use of modules in learning basically aims as a means of independent learning so that students have the motivation to learn and improve learning outcomes [7].

On the other hand, implementing STEM learning requires self-regulated learning [8][9]. Self-regulated learning is a planning process in learning, monitoring and implementing it using learning strategies [10][11]. Several studies have proven that students who apply self-regulated learning are proven to be effective in improving learning outcomes [11][12][13]. Because of the importance of self-regulated learning, so it requires in teaching and learning. Especially for students at Islamic Boarding Schools based on *Tahfidz* Islamic Boarding Schools who have solid routines and a heavier study load than schools in general. The existence of targets in the learning process, requires a self-regulated learning in order to both formally and *tahfidz* can be optimize. Therefore, researchers are interested in conducting research on the development of self-regulated learning Physics-STEM Module to improve creative thinking skills. For detailed mind map about the importance of this research is depicted in Figure 1. For detailed mind map about the importance of this research is depicted in Figure 1.

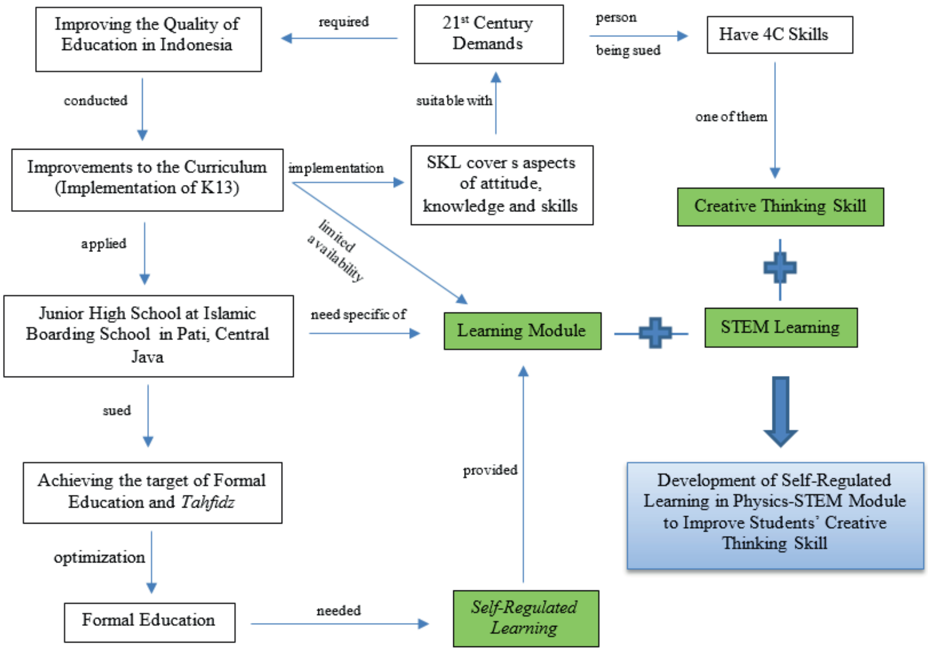


Figure 1: Mind map of this research.

2. RESEARCH METHOD

This research uses mix method with a sequential exploratory design [14]. It is intended to obtain qualitative data and quantitative data. Qualitative data is needed to design self-regulated learning in physics-STEM module suitable analysis of needs. During analysis of needs stage, this is accomplished through direct field studies in Junior High School at Islamic Boarding School. The Islamic Boarding School is located on Pati, Central Java. Then, it followed by interviews with physics teachers and using questionnaires to students. Quantitative data is used to determine the validity of the module feasibility. This study has only reached the expert validation stage and it has yet to be used in learning. The research design is depicted in Figure 2.

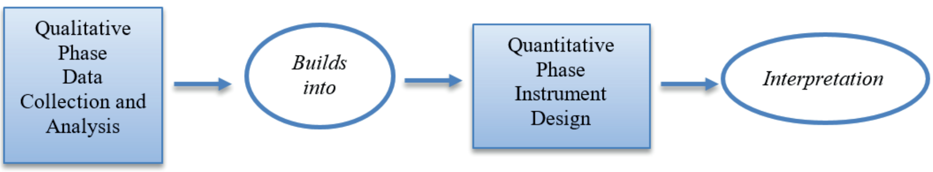


Figure 2: Research design (sequential exploratory).

The participants who involved in this research were 3 lecturers of expert validator. Three lecturers of expert validator participate in validating the module's feasibility. The module validation sheet was used to assess the feasibility of integrating Self-regulated Learning in Physics-STEM Module. The completed module draft is validated by an expert validator using the module validation sheet. The module validation sheet includes several aspects, they are: (1) the material's suitability with STEM (science, technology, engineering, and mathematics); (2) the module's conformity with SRL (self-regulated learning); and (3) the feasibility of teaching materials, including: a) the dimensions of attitude, knowledge, and accuracy of the material; b) module presentation, and c) language. In addition, a readability test sheet is also used to determine the level of student understanding.

The Aiken validation technique is used in the expert validation module's feasibility analysis. The Aiken formula is used to calculate the content coefficient value based on the results of the validator's assessment. According to Aiken's V formula [15] is used to calculate the content-validity coefficient based on the results of an expert panel of n people's assessment of an item in terms of how well it represents the construct being measured. Aiken's formula is:

$$V = \frac{\sum s}{(c-1)} \tag{1}$$

Description:

$$V \quad = Aiken\ validation\ value$$

$$n \quad = number\ of\ raters$$

$$c \quad = the\ highest\ number\ of\ rating\ categories\ formulated\ by\ Aiken$$

$$\sum s = (r - l_0)$$

$$r \quad = the\ number\ provided\ by\ the\ validator$$

$$l_0 \quad = the\ smallest\ number\ of\ rating\ categories\ formulated\ by\ Aiken$$

The module validation calculations' results are then interpreted using validation result criteria according to [16] based on table 1.

If the validation results are in the very high, high and sufficient category, so the module is included in the valid criteria, then it is feasible to use. However, if the validation results are in the low and very low categories, the module is invalid, so it is not feasible to use.

3. RESULT AND DISCUSSION

Table 1: Validation result criteria.

The Number of Rating	Categories
0.8 – 1.00 0.6 -- 0.799	Very high
	High
0.4 – 0.599 0.2 -- 0.399	Moderate
	Low
<0.20	Very Low

3.1. Analysis of Needs

The development of learning modules must take into account existing problems and analysis of needs in order for the module to be suitable for use by teachers in teaching and learning activities [17]. In this research, analysis of needs covers of the application of STEM learning, module needs, scope of material that needs to be developed, the importance of self-regulated learning, the efforts that can be made to improve creative thinking skills.

Based on the results of interviews conducted by researchers with physics teachers in Junior High School at Islamic Boarding School. It was concluded that students' interest in learning physics was still low. It is caused by several factors such as the limitations of existing practicum tools, limited teaching materials/modules that support learning, the density of student activities. Which includes formal and *tahfidz* activities as well as the condition of the mental burden of students on the target of memorizing *tahfidz*. This is in line with the researcher's experience as a physics teacher at the school. Because of that it needs to integrating self-regulation learning in teaching and learning in order to both formal learning and *tahfidz* can run optimally.

The other result shows that teaching and learning at the school has not implemented STEM. Besides that, it hasn't self-developed module. So, it's important to develop the self-regulated learning Physics-STEM Module

3.2. The Feasibility of Integrating Self-regulated Learning Physics-STEM Module

The feasibility of module includes three components are: (a) the material's suitability with STEM; (b) the module's conformity with SRL (self-regulated learning), and (c) the feasibility of teaching materials. Each component has subcomponents. The material's suitability with STEM consists of STEM structure, STEM definition, explanation of material position and material preparation. The module's conformity with SRL (self-regulated learning) consist of forethought phase, performance phase and self-reflection phase. The feasibility of teaching material consists of the dimensions of attitude, knowledge and material accuracy; presentation component and language component. Components of the dimensions of attitude, knowledge and material accuracy covers dimensions of attitude, dimension of knowledge, material accuracy, up-to-date and contextual, compliance with laws and regulations, and skill dimension. Presentation component cover presentation technique, material presentation support, presentation of learning and serving equipment. Language component cover conformity with the level of development of students, communicative, dialogic and interactive, straightforward, coherence and luck of the line of thought, conformity with Indonesian language rules, and use of terms and symbols/symbols.

In the validation process with experts there are several inputs for improvement. Then, researchers make improvements to the module in according to the suggestions given. The improvement suggestion to the module are as shown in the table 2.

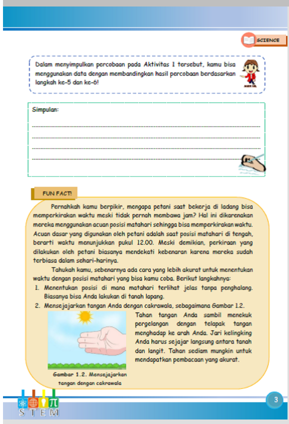
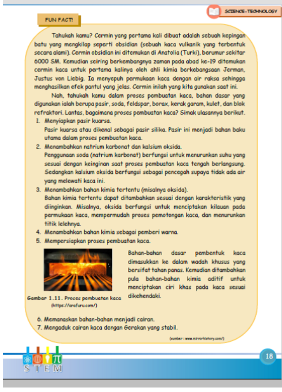
Then, the feasibility of module based on Aiken validation can be seen in the Table 3.

According to Table 3, the validation results from three experts indicate that Self-Regulated Learning in Physics-STEM Module has very high criteria, so the module is included in the valid criteria, then it is feasible to use. The validation data show that the material's suitability with STEM have a validation value of v = 0.88 in the very high category. Then, component of the module's conformity with SRL (self-regulated learning) has a value of v = 0.87 in the very high category, as does the instrument the feasibility of teaching materials, which has an average validation value in the very high category. Thus, experts can conclude that the module's feasibility is in the very high category, so the module is included in the valid criteria, then it is feasible to use. Before the module is implemented in learning, the module is carried out a readability test first.

In this study, the module readability test was carried out using a sample of 15 students using the module in printed form. In the module testing process, students are asked to read the module on each page. After the students finished reading one page, the students filled out the readability test sheet to fill in the responses in the form of "understand or not understand" the sentences contained in the module. Then students write the main idea on the page. The results of the module readability test for 15 students are shown in Table 4.

Based on Table 4, it can be seen that the results of the readability test of students who understand are 94% in the high category. So, it can be concluded that the developed module is easy to understand by students.

TABLE 2: Module improvement by experts.

Validator	Improvement Suggestions	Description	Picture
1	there are still some typos	already repaired	-
	need to be added of engineering aspects	already repaired	
2	no revision	-	
3	added time calculation process	already repaired	
	added rock components that make up the mirror	already repaired	

4. CONCLUSION

The feasibility of self-regulated learning Physics-STEM Module is in very high category, so the module is included in the valid criteria, then it is feasible to use. For component of the material's suitability with STEM have a validation value of v = 0.88 in the very high category. Then, component of the module's conformity with SRL (self-regulated

Table 2: Continued.

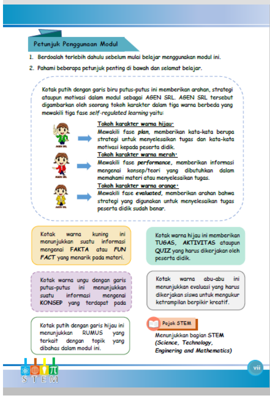
<table>
<tr><th>Validator</th><th>Improvement Suggestions</th><th>Description</th><th>Picture</th></tr>
<tr><td></td><td>added electron microscope</td><td>already repaired</td><td>
SCIENCE-TECHNOLOGY
FUN FACT!
Tahukah kamu bahwa mikroskop untuk pertama kalinya ditemukan oleh Zacharias Janssen dan Hans Janssens pada tahun 1590. Mikroskop ini terdiri dari dua lensa obyektif dan mampu memperbesar hingga 150 kali. Penemuan ini mendorong Galileo untuk membuat mikroskop dari lensa optik pada tahun 1609. Namun mikroskop Galileo hanya memiliki kemampuan terbatas dalam memperbesar bayangan, tidak bisa mengamati ukuran dibawah 200 nm.
Di tahun 1632-1723, Antony Van Leeuwenhoek mampu membuat mikroskop dengan perbesaran hingga 300 kali sehingga mampu melihat benda-benda yang kecil. Bahkan dari mikroskop buatannya ini Antony dapat menggambarkan sperma (atau spermatozoa) dari hewan dan manusia untuk pertama kali.
Pada tahun 1931, Ernst Ruska dan Max Knoll berhasil membuat mikroskop elektron. Mikroskop elektron adalah mikroskop yang mampu melakukan perbesaran objek hingga 2 juta kali, yang menggunakan elektro statik dan elektro-magnetik untuk mengontrol pencahayaan dan tampilan gambar serta memiliki resolusi yang jauh lebih bagus daripada mikroskop cahaya. Mikroskop elektron ini menggunakan jauh lebih banyak energi dan radiasi elektromagnetik yang lebih pendek dibandingkan mikroskop cahaya.
Mikroskop electron dibedakan menjadi dua jenis, yaitu *Scannning electron microscope (SEM)* dan *Transmition electron microscope (TEM)*. Komponen utama yang sama antara SEM dan TEM adalah sumber elektron, serangkaian lensa elektromagnetik dan elektrostatik untuk mengendalikan bentuk dan lintasan berkas elektron, elektron apertur. Semua komponen ini berada di dalam ruang yang berada di bawah vakum yang tinggi. Prinsip kerja mikroskop elektron adalah penggunaan berkas elektron untuk pembentukan gambar.
Gambar 1.23. Mikroskop elektron
STEM 51</td></tr>
<tr><td></td><td>need the orange agent SRL color to be changed to yellow</td><td>already repaired</td><td>
Petunjuk Penggunaan Modul
1. Berdoalah terlebih dahulu sebelum mulai belajar menggunakan modul ini.
2. Pahami beberapa petunjuk penting di bawah dan selamat belajar.
Kotak putih dengan garis biru putus-putus ini memberikan arahan, strategi ataupun motivasi dalam modul sebagai AGEN SRL. AGEN SRL tersebut digambarkan oleh seorang tokoh karakter dalam tiga warna berbeda yang mewakili tiga fase *self-regulated learning* yaitu:
Tokoh karakter warna hijau: Mewakili fase **plan**, memberikan kata-kata berupa strategi untuk menyelesaikan tugas dan kata-kata motivasi kepada peserta didik.
Tokoh karakter warna merah: Mewakili fase **performance**, memberikan informasi mengenai konsep/teori yang dibutuhkan dalam memahami materi atau menyelesaikan tugas.
Tokoh karakter warna orange: Mewakili fase **evaluated**, memberikan arahan bahwa strategi yang digunakan untuk menyelesaikan tugas peserta didik sudah benar.
Kotak warna kuning ini menunjukkan suatu informasi mengenai FAKTA atau FUN FACT yang menarik pada materi.
Kotak warna hijau ini memberikan TUGAS, AKTIVITAS ataupun QUIZ yang harus dikerjakan oleh peserta didik.
Kotak warna ungu dengan garis putus-putus ini menunjukkan suatu informasi mengenai KONSEP yang terdapat pada
Kotak warna abu-abu ini menunjukkan evaluasi yang harus dikerjakan siswa untuk mengukur ketrampilan berpikir kreatif.
Kotak putih dengan garis hijau ini menunjukkan RUMUS yang terkait dengan topik yang dibahas dalam modul ini.
Pojok STEM
Menunjukkan bagian STEM *(Science, Technology, Enginering and Mathematics)*
STEM vii</td></tr>
</table>

Table 3: The feasibility of modul.

Number	Component	Validation	Category
1	The material's suitability with STEM	0.88	Very high
2	The module's conformity with SRL (self-regulated learning)	0.87	Very high
3	The feasibility of teaching materials	0.88	Very high
	the dimensions of attitude, knowledge, and accuracy of the material		
	module presentation	0.86	Very high
	language	0.88	Very high

Table 4: Physics-STEM module integrated self-regulated learning readability test results.

Student Category	Percentage of Readability Test Results (%)	Criteria for Readability Test Results
Understand	94	High
Not Understand	6	

learning) has a value of v = 0.87 in the very high category, as does the instrument the feasibility of teaching materials, which has an average validation value in the very high category. In other hand, the results of the readability test of students who understand are 94% in the high category. So, it can be concluded that the developed module is easy to understand by students. Based on these results, the module is suitable for use in teaching-learning.

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