Analysing students' feedback: Their motivations and interests in STEM-based learning

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Abstract. Student motivation and interest are essential components that contribute to the successful application of STEM-based learning, and they can be obtained through students' feedback. Through feedback analysis, this study aims to obtain information about students' motivation and interest in STEM-based learning activities. This survey research was conducted at one of Islamic high school in Aceh province. The research instrument was in the form of open-ended questions, amounting to four questions. Data were analyzed using an inductive approach. The results showed that students considered STEM-based learning to be fascinating because it trained them to think critically, creatively, and systematically, and relate to the real world. They also want to learn more about STEM-based biology learning. On the other hand, they think that teachers need to pay attention to learning facilities and techniques when carrying out STEM-based learning activities so that learning can run effectively. The results of this study inform teachers, lecturers, and education administrators to design effective STEM-based learning activities.

1. Introduction
Currently, STEM education is transforming with an emphasis on enhancing positive attitudes towards STEM by increasing the number of students choosing STEM courses and careers [1]. Therefore, student motivation and interest are important components that contribute to the successful application of STEM-based learning [2]. Therefore, research on students' attitudes, motivation, and interest in STEM learning is very important.

Information about student attitudes, motivation, and interest in a learning process can be obtained using feedback [3]. Feedback used in an educational context is a key strategy for increasing knowledge and skill acquisition [4,5]. Besides, the feedback has been recognized among researchers as a potentially powerful tool for enhancing student learning and reducing the gap between where students are and where they need to be [6]. Furthermore, students' feedback is also used as a strategy to do a self-evaluation in improving teacher's professionalism in teaching [7].

Information related to student feedback from STEM-based learning is still limited. STEM research has focused on designing STEM training programs [8]. Furthermore, the results of the systematic literature review conducted by Li et al. [9] indicates that 47% of the topic articles about
STEM discuss goals and policy, curriculum, evaluation, and assessment (including literature review). However, it does not specify what forms of evaluation and assessment have been widely used. Research conducted by Roberts et al. [2], the source of this research instrument, was indeed using student feedback as one of the data sources. However, the context is different from this research. Roberts' research focused on informal learning activities, while this study is a formal learning activity.

Based on this information, there is information that needs to be explored regarding STEM-based learning. Therefore, this study aims to obtain information about students' motivation and interest in participating in STEM-based learning through student feedback analysis. The results of this study are beneficial for teachers, lecturers, academics in developing practical STEM-based learning activities.

2. Research Design
This study employs a qualitative approach with a cross-section survey [10]. Data were collected when students had finished implementing STEM-based learning activities in Biology lessons.

2.1. Research Participants
The sample is chosen using a non-probability sampling with the purposive sampling technique. The sample came from one class consisting of 54 students of grade 10th of an Islamic Senior High School in Aceh province.

2.2. Research Instruments
The research instrument was adopted and modified based on the session reflection form used by Roberts et al. [2]. This instrument consists of four open-ended questions.

2.3. Data Collection
Data were collected after the teacher completed the learning process. Students are asked to write their answers on the answer sheet that has been given.

2.4. Data Analysis
Data analysis used a general inductive analysis approach. This approach intended to allow the findings emerging from frequent, dominant, or significant themes inherent in raw data, without the constraints imposed by structured methodologies [11]. This process consists of reducting, organizing, and connecting the data [2]. All student feedback was transferred from the answer sheet to Microsoft Excel as raw data. Furthermore, we processed the raw data using NVivo 12 software for transcription and coding of research data.

3. Results and Discussion
To present the results and comprehensive discussion, we classify the results and discussion based on the questions from the following instrument: (1) student responses related to new things they have got from STEM-based learning; (2) what students do not like about STEM-based learning; (3) what students learn from STEM-based learning activities; and (4) the desire of students to study the material given or biology content further.

3.1. New things that students learn from STEM-based learning activities
The feedback given by students regarding what students have just learned from STEM-based learning activities focuses on two categories, including biology material and STEM concept. Student responses that focus on biology material can be seen from the following statements.

- "About diseases and activities of the motion system and how the movement system works." (Student No.2)
- "I learn about the skeletal muscle and joints in more depth and detail." (Student No.4)
- "Regarding the bone grouping, the process of bone formation, muscle characteristics, and various disorders of the movement system." (Student No.23)
The feedback displayed shows that the form of the response given by students is still simple and recalled the learning objectives. The opinion of "New thing" is more likely pointed to something new as it has never been taught before.

STEM learning has recently been applied in Indonesia, especially in Aceh. Therefore, the responses given by students tend to be on the abbreviation of STEM itself. More specifically, they responded to the concept and purpose of STEM. Those responses can be seen as follow:

- "I learn about the combination of science, technology, engineering, and mathematics which is combined into one problem in teaching materials and student worksheets." (Student No. 8)
- "In the STEM system, I studied four discussions, namely science, technology, engineering and mathematics in STEM combining them into one learning medium." (Student No. 19)
- "STEM education is an integrated learning approach between science, technology, science and mathematics …" (Student No. 20)
- "STEM is an integrated learning approach between science, technology, engineering, and mathematics …" (Student No. 21)

Relating to students' feedback of the STEM goals, students think STEM learning can improve their critical, creative, and systematic thinking skills. Also, STEM-based learning is considered to support their problem solving skills, increase their vision, connect with the real world.

- "What I learned with STEM, I can practice developing creativity …" (Student No. 22)
- "I learned many things from learning with STEM that I had never previously known,…learning with STEM can increase student attention to the interaction of engineering technology science (and) enhance critical thinking skills …" (Student No. 37)
- "In a learning process like this we can think systematically …" (Student No. 28)
- "Learning with STEM can deepen and increase knowledge of the interaction of science technology and students have the opportunity to experience various ways of learning and problem solving" (Student No. 50)
- "What I learned with STEM, I can find out and understand the development of bones in the body …" (Student No. 3)
- "… STEM learning is a bridge between education and the real world" (Student No. 1)

Associated with students' feedback regarding the concepts and objectives of STEM, it shows that students are interested in STEM learning. Thus, they consider STEM as something new for them. These responses are beneficial for teachers, researchers, and STEM-based learning activists as positive feedback.

However, there is an uncategorized response which is neither positive nor negative statement. The response stated as follow: "Actually I barely know some information, such as the parts of the cell and that's just how much is remembered and a deeper explanation" (Student No. 15). The statement indicated that students might lose concentration in learning activities participation. Therefore, it is suggested that teachers should monitor students' concentration while participating in learning activities regularly.

3.2. What students do not like about STEM-based learning activities

The feedback given by students regarding things that students do not like gives an extraordinarily complex variation of answers. Therefore, we divided their feedback regarding this question into two categories: positive and negative feedback.

Student positive feedback shows that students' interest in STEM-based learning that has been done by the teacher. The statements of student positive feedback are as follows:

- "Nothing, because in my opinion, STEM brings the latest innovations to the world of education. STEM learning is amazingly effective and easy to understand. It can increase achievement and interest in learning. Because of STEM learning, students are more enthusiastic because they can be directly involved in the manufacturing process" (Student No. 17)
"Nothing, because for me this is quite fun. So far, STEM has brought innovations into the world of education. It has been learned that this learning system is highly effective in increasing student achievement and interest in learning and student memory …" (Student No. 21)

These positive results indicate that students consider STEM-based learning as an innovation in education. Therefore, STEM-based learning must be implemented based on the latest novelties, so that students are interested and actively participate in STEM-based learning activities.

On the other hand, Students' negative feedback is influenced by the facilities and the learning activities carried out by the teacher. Facilities such as the quality of the internet network, internet quotas, and ownership of technology could discourage students from involving in STEM-based learning activities. The statements from the students' feedback are as follows.

- "… there are some students (who) cannot afford to have the learning facilities" (Student No. 38)
- "… The limited facilities owned by students can also hinder STEM learning" (Student No. 39)
- "I think learning with this system will require a lot of facilities and some students cannot afford those facilities to support learning …" (Student No. 51)
- "The process (learning and teaching) feels more like an online task than online learning, so it depends on the internet network" (Student No. 14)
- "… many constraints on facilities such as quotas and networks" (Student No. 37)
- "… even with STEM, we must have a lot of quotas, which are quite expensive" (Student No. 10)
- "… expensive data package costs" (Student No. 16)
- "… there are also many students who do not have gadgets" (Student No. 36)
- "… There are students whose facilities are lacking because not all students have cellphones or laptops" (Student No. 55)

Based on student feedback, educational facilities are still an obstacle in learning activities, especially learning activities that use technology, such as STEM-based learning. Furthermore, not only students but teachers also have obstacles related to technological facilities. A research finding by Nugroho et al. [12] shows that 65% of Indonesian teachers say that the education infrastructure in Indonesia is still inadequate. So, teachers need to prepare and pay attention to facilities and their students' abilities in carrying out technology-based learning activities.

Students' negative feedback also come from teacher learning techniques and methods. It impacts on students difficulty to understand and to communicate with teachers and fellow students; the questions given are too complicated and use too many scientific terms. As a consequence, learning activities became ineffective. The statements of student feedback regarding these problems are as follows.

- "In my opinion, learning activities with STEM are very complicated and difficult to understand." (Student No. 29)
- "…sometimes there is still a language that I cannot understand, (where) at this time, a little direct interaction (with the teacher) in learning makes it difficult for me to understand it quickly." (Student No. 48)
- "It is difficult to discuss with the teacher because learning was conducted using digital technology." (Student No. 4)
- "Lack of connection with other students." (Student No. 5)
- "What I don't like about STEM is that I don't understand a lot of questions." (Student No. 22)
- "In my opinion, STEM-based learning makes many students do not understand, and many are confused." (Student No. 55)
- "About the learning method because I've never used a method like this, so it's a little confusing." (Student No. 8)

The negative feedback from students is elaborated to the obstacles of learning activities such as techniques and methods. Networks and internet quotas facilities, as well as ownership of technology,
are the inhibiting factors for learning activities in terms of technology. Furthermore, learning techniques and methods are inhibiting factors from a pedagogical perspective. In other words, teachers still have weaknesses in pedagogical and technological knowledge. Therefore, teachers need to give more attention to their pedagogical and technological skills.

Teachers can learn about using the Technological Pedagogical Content Knowledge (TPACK) framework to improve their pedagogical and technological skills. In fact, through the TPACK framework, they can also increase their content knowledge. Yulisman et al. [13] stated that the professional abilities of junior high school teachers in Banda Aceh were dominated by content knowledge, followed by technological knowledge, then pedagogical knowledge. His finding is consistent with the results of this study that teachers need assistance from related parties to improve their pedagogical and technological knowledge.

3.3. What students learn from STEM-based learning activities

Student feedback regarding what students learn from STEM-based learning activities shows mixed results, both positive and negative. Interestingly, their responses were dominated by positive responses.

Students' positive responses consisted of two major focuses, namely focusing on thinking skills and biology material. Student responses that focus on thinking skills show that students consider STEM-based learning to be able to improve their thinking skills. Student feedback shows that STEM-based learning by teachers helps them improve their thinking skills. They also think that STEM-based learning also helps them to improve their problem-solving skills through scientific investigation. The following is statements of student feedback.

- "I can study a variety of problem solving by scientific investigation and with the context of applying mathematics" (Student No. 11)
- "... I also learned about how to find solutions to problems through innovation and design, as well as the linkages between assessment, study plans, and learning standards." (Student No. 20)
- "What I learned from this learning activity is problem-solving based learning that deliberately places scientific inquiry and the application of mathematics in the context of designing technology as a form of problem solving." (Student No. 26)

Based on the above snippet, it appears that students believe they can improve their thinking skills. In this case, problem-solving skills can be improved through investigative activities and innovations. These results indicate that providing stimuli or linking simple investigative activities to STEM-based learning activities can increase students' confidence in terms of increasing their thinking skills.

Furthermore, student responses that focus on biology material show that the STEM-based learning activities that have been carried out by the teacher provide new knowledge and concepts about the material taught. Although the answers given by students is simple, those can be used as an indicator of the success of implementing STEM-based learning. The statements of student feedback related to biology materials and concepts are as follow.

- "I learned about the movement system in the human body" (Student No. 4)
- "Regarding the motion system, the structure of the human body, joints and other motion systems" (Student No. 5)
- "... Movement system, muscles, and others" (Student No. 6)
- "What I studied was the division of the bones, the number of bones, human joints and other systems of motion." (Student No. 1)
- "I studied the movement system in humans. Every human body has two types of locomotion, namely active and passive locomotion. Active tools such as muscles, while passive tools in the form of frames and bones, these two types of motion can form a movement system" (Student No. 6)
- "I learned about the motion system in humans, namely that there are bones as passive motion and muscles as an active motion" (Student No. 10)
Apart from positive feedback, some students still find problems related to STEM-based learning. The statement is: "Making students confused in understanding the learning material because of a lack of experience in the facility." (Student No. 50). Based on this student feedback, STEM-based learning activities must consider the circumstances and facilities that students have. It is essential to support the successful application of STEM-based learning.

3.4. Students' interest in studying further materials and topics
In general, all students' feedback about their interest in studying biology material or topic in a more advanced manner shows positive responses. These results indicate that the teacher succeeded in attracting students' attention to have in-depth learn about biology. Biology materials such as skeletal system topic, tend to be monotonous and often make students feel bored quickly. However, with the application of STEM-based learning, stereotypes can be changed.

Specifically, student feedback shows different positive responses. Students' interest in studying biology material is based on their assumption that this material can be useful in their daily life. Furthermore, they want to add insight into this material and want to deepen the material in the future. Besides, the use of different learning media can give a positive impression to students so that they are interested in studying different biology material or topic. Student feedbacks are shown as follows.

- The feedback of students who are interested in studying other material because it can help them in real life is as follows.
  - "Yes, I will learn more about this material or biology topic because it is beneficial, especially in our daily lives." (Student No. 6)
  - "Yes, because this material is interesting to apply in our everyday life. So, knowing the correct sitting position, why we experience neck pain when we wake up and therefore, it is important to learn about the movement system." (Student No. 8)
  - "Of course, because I want to increase my knowledge about this material so that I can apply it in my daily life properly." (Student No. 21)
  - Feedback of students who are interested in studying different material because they want to deepen the material is as follows.
    - "Yes, because there is much more to learn, so it is necessary to continue studying this science." (Student No. 19)
    - "Yes, because I feel that there are some parts that cannot be understood" (Student No. 26)
    - "Yes, I will learn more about this material, Insha Allah because I still have a shallow understanding of this material" (Student No. 44)
  - The feedback of students who are interested in studying other material because they want to increase their insight is as follows.
    - "Yes, because knowledge about living things will affect as long as we are alive and need to add deeper insights" (Student No. 3)
    - "Yes, so that my knowledge and insight can increase by reading other sources of information" (Student No. 12)
    - "Yes, because it will broaden my insight into the human movement system" (Student No. 13)
  - The feedback of students who are interested in studying other material using other assistance is as follows.
    - "Yes, I will study it further by watching the instructional video because I don't understand it just by reading this material." (Student No. 10)
    - "Yes, I will learn more about this biological material frequently so that it can be remembered, and this material is also useful for everyday life." (Student No. 37)

The feedback given by students regarding their interest in continuing to study biology material showed fascinating results. In general, they are interested in the material because it can be useful for their daily lives, likewise, with their interest in deepening this material. Even though they do not fully understand the material, they are still interested in deepening it. This finding shows that contextual
learning will be popular and increase students' interest in learning it. The results of this study are in line with the research results of Saptarini et al. [14], which shows that 63% of students feel that STEM-related subjects are considered more difficult than other subjects. However, students still take STEM-related subjects at school. They consider it as a challenge for mentally advanced high school students.

4. Conclusions
The results of this study indicate many new things that have been obtained by students from STEM-based learning activities. These results indicate students are interested in participating in STEM-based learning activities because it trains them to think critically, creatively, and systematically. They also want to learn more about STEM-based biology learning. On the other hand, they think that teachers need to pay attention to facilities and techniques as well as learning when carrying out STEM-based learning activities so that learning can run effectively. The results of this study inform teachers, lecturers, and education administrators to be able to design effective patterns of STEM-based learning activities.

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