Students' Participation in STEM Integrated Science Learning: How Do Students Act?

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Abstract. The STEM approach is one of the learning methods that can develop students' critical thinking and activeness. The activeness of students in STEM learning can be seen in the form of student participation. This study aims to determine the form of student participation in STEM-integrated science learning and explain the differences in the profile of student participation in in-service and pre-service STEM-integrated science learning. This research method uses a qualitative case study approach. The sampling technique used purposive sampling with data collection techniques using observation, interviews, and documentation. The participants are two groups of junior high school students, each from in-service and pre-service teachers during STEM integrated science learning. The data analysis technique used is pattern matching and explanation. The profile of student participation in STEM is divided into 2: student participation as engineers and technicians. The study's findings are that each student in the group taught by pre-service and in-service teachers has their participation, some are participating as engineers and some are technicians. In conclusion, the participation of students as engineers and technicians in in-service and pre-service teachers STEM integrated science learning raises the same characteristics.

Keywords: Student Participation, Technician, Engineers, STEM, Science Learning

1 Introduction

Society 5.0 is a vision that combines new technologies in industry and social activities to achieve the Sustainable Development Goals proclaimed by the United Nations (UN). Society 5.0 is defined in terms of solving social problems of modern society, which in practice can enable the creation of new values or things through innovations that focus on providing and serving community needs [1]. The primary key of Society 5.0 is innovations that are created to address the problems that exist in modern society that are

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centered on humans, not machines. Innovations created to deal with a problem can be trained in children through learning efforts in education.

Education in Indonesia currently uses the 2013 curriculum, an improvement from the previous curriculum, namely the Education Unit Level Curriculum. As a result of the regulation regarding the change of the 2013 curriculum, the government issued Permendikbud No. 22 of 2016 concerning Standards for Primary and Secondary Education which states that in the core activities, the approach used is the scientific approach, and the learning model used is the inquiry learning model, discovery, project-based learning and problem-based learning [2]. However, it is possible to use other approaches, such as the STEM approach.

STEM is a learning approach that uses science, technology, engineering, and mathematics based on the relationship between disciplines and real-world problems. STEM has four principles, referring to a combination of learning objectives, content, and practices from various STEM disciplines, involving students in learning environments based on real-world problems, inquiry-based learning, and design-based learning [3]. The existence of student activities in engineering design allows them to learn from failure and participate in redesign to solve a problem and promote communication and teamwork skills that are important in Society 5.0 [4]. However, STEM learning is rarely applied in Indonesia.

STEM learning is not explicitly stated in the Permendikbud and other 2013 Curriculum documents, so teachers have no obligation to use STEM. In addition, some science teachers argue that the difficulties in implementing STEM learning are the less long learning time, the supporting facilities, the teacher's ability to integrate STEM, and the student's abilities in mathematics [5]. Other research shows that in Indonesia, STEM learning is more prevalent among high school students than junior high school students; it seems that junior high school students are not fully ready for STEM learning because only 14 out of 55 junior high school teachers have implemented STEM learning [6]. Even though STEM learning is one of the lessons that can develop critical thinking and logic and students' activeness in various fields of knowledge, this follows the 2013 curriculum, which emphasizes student activity and student-centered learning [7]. STEM can improve student learning activities because during the STEM learning process activities occur such as arguing, asking questions, and discussing solving problems that have been presented according to problems in everyday life. making it easier for students to understand the material [8]. Other advantages of STEM-integrated science learning are increasing student collaboration and creating a product to solve problems in everyday life [9], [10]. This collaboration between students makes the learning process more active because students participate in group learning and discussion to complete assigned projects or problems. Collaborative learning can also help students reach their potential level of development.

According to Vygotsky [11], learning activities that involve student participation produce a lot of internal development processes that can only function when children interact with people in their environment and work together with their peers. Vygotsky also introduced the zone of proximal development, which is the distance between the actual developmental level of the child and the potential level of development. The actual developmental level is determined by independent problem solving while the

potential developmental level is determined by adult supervision or collaborative problem-solving with peers. Collaboration between students will make students have their respective roles or participation.

This form of student participation involves interaction with each member of the group to create a frame. The term frame is described by Goffman [12] as a process in which the interlocutor determines the situation that occurs. While engaging in interactions, participants will frame events and negotiate the interpersonal relationships that shape these events in ways that are expressed in the way they manage the reception of speech or input. Previous research on student participation is related to science process skills (SPS). SPS is a way to acquire scientific knowledge, a fundamental skill that facilitates science learning, allows active student participation, develops a sense of responsibility, improves learning activities, and provides research methods [13]. SPS includes skills such as the stages of the scientific approach, namely observing, making hypotheses, measuring, communicating, classifying, and predicting [14]. This study [14] also explained that the overall SPS of elementary school students in the Sumedang Regency was still low, and this low SPS score was unrelated to gender differences. In addition, the latest research on SPS in junior high schools in the medium to high category with SPS aspects includes observing, formulating problems, formulating hypotheses, designing experiments, communicating, and drawing conclusions [15].

There are two forms of student participation in learning the STEM approach: engineers and technicians [16]. The form of participation as an engineer reflects STEM, where the unique feature of STEM is the design in it. This role is because engineers will be involved in solving problems and designing them, while technicians are only limited to practical and functional considerations [16]. The reason for choosing the two participations is because of the STEM challenges in the future where according to Society 5.0, humans are required to create innovations to solve problems in everyday life that engineers and technicians can create can assist in realizing the system. In addition, student participation can increase because the two forms of participation work together. However, this study was limited to two student participation forms involving two students. Therefore, the researcher wants to know the form of student participation in STEM-integrated science learning by involving more than two students and to explain the profile of student participation in in-service and pre-service STEM-integrated science learning. This research is essential to know the level of student participation. It is expected to be able to direct the participation of all students towards the participation of engineers because this participation is by the existing learning, and students can understand the learning material in depth.

2 Research Method

The approach used is qualitative with the type of case study research. This study uses a single case study because it only observes one group of students with the same case, namely the form of student participation in STEM-integrated science learning. The sampling technique used is purposive sampling. The selected sample is a heterogeneous group based on the ability of students in junior high schools in Surakarta who do STEM

learning on in-service and pre-service teacher learning. The criteria for in-service teachers who are in charge of STEM integrated science learning classes include science teachers who have at least two years of teaching period with a minimum face-to-face teaching load of 24 hours face-to-face per week [17] and science teachers who have attended training, workshops or seminars on STEM with the assumption that they have attended at least two times. This training is crucial because it relates to teacher performance, and the frequency of attending training, workshops, and seminars is related to student academic achievement [18], [19]. Therefore, the more workshops and seminars attended, the more skilled teachers will be in carrying out learning.

The criteria for pre-service teachers include currently carrying out STEM-integrated science learning, having attended STEM workshops at least three times, and having passed microteaching and school internship courses. From these criteria, it was found that one in-service teacher and one pre-service teacher taught at the same junior high school in Surakarta. The group of in-service teachers observed was group 5, consisting of 5 students with heterogeneous midterm exam scores. However, one student was not included in the sample among the five students. This exclusion is because the student at the second meeting didn't participate in learning activities because of illness. So from 5 students, only four students were used as samples. The student we call Bim, Wan, Dya, and Fia with Bim has the highest midterm exam score, and Fia has the lowest. For pre-service teachers, group one with five students with heterogeneous midterm exam scores was observed. The students we call Vin, Ari, Ran, Al, and Lia with Ran have the highest midterm exam score, and Ari has the lowest.

Data collection techniques used direct observation, interview techniques, and documentation. Direct observations on the STEM integrated science learning process from the beginning to the end of the lesson during the STEM project work on a group of students from one of the junior high schools in Surakarta. After that, at the end of STEM learning, interviews were conducted directly with students regarding the STEM integrated science learning process that had been carried out. Then the interview continued with the science teacher in charge of STEM-integrated science learning about student participation in class. The interview used is the type of focused interview.

The validity test used to validate the observation sheets and interview guides for teachers and students used Gregory content validity by two validators. Then the observation data was tested for dependability using inter-rater reliability with a Kappa coefficient of 0.80. Data analysis involves testing, categorizing, tabulating, or combining evidence [20]. The data analysis technique used in this study uses pattern matching, and explanation makes.

3 Finding

3.1 Student Activities in Integrated Science Learning STEM In-Service Teacher

The research was conducted at a junior high school in Surakarta in one of the 7th-grade groups guided by an in-service science teacher who carried out STEM-integrated science learning on the Solar System topic. STEM integrated science learning activities are carried out in two meetings, each meeting for 2 hours of lessons or 90 minutes.

Meeting 1.

The first meeting discussed the Solar System topic the teacher had previously given. The approach used is STEM with a discovery learning model with the sub-topic Effects of Rotation and Revolution of the Earth, and the moon is an initial meeting to build collaboration between students. When the seats for the group have been determined, Bim, Wan, Fia, Ray, and Dya immediately place themselves and continue working in groups. When the camera is placed in front of the seat, they are immediately awkward and silent for a while to have a little discussion.

1 *Ray: pointing to the top eclipse picture, "this is a lunar eclipse; the earth is blocking light from the moon."*

2 *Bim: "This is a lunar eclipse. Oh yeah, this is it" (points to the writing on the book, then gives the book to Ray).*

3 *Ray: "Usually, if there is a solar eclipse, it will damage the eyes."*

...

7 *Ray: "The lunar eclipse?"*

8 *Bim: "It is the solar eclipse."*

From the number 1 and 5, it can be seen that Ray has shared his ideas several times to fill out the worksheets distributed by the teacher. Initially, Ray shared the idea of an image that included a lunar eclipse and the impact of a solar eclipse. Bim is also seen sharing his idea to improve Ray's opinion (8). Initially, Ray thought that the effect on photosynthesis was the impact of a lunar eclipse, then Bim corrected that it was the effect of a solar eclipse. In addition to these interactions, there are collaborative interactions in the form of a division of tasks.

10 *Ray: "who wants to write?"*

11 *Bim: "Me"*

12 *Ray directed the answer that Bim would write. When finished, Bim gave the worksheet to Ray.*

Ray at number 10 built a collaboration by asking who would take on the task of writing. In this case, Bim is always at the forefront to take over the task (11). The first meeting ended with Wan sharing ideas about the impact of a lunar eclipse and Bim checking the worksheet before it was collected. This meeting was dominated by the interactions of Ray, Bim, and Wan, while Fia and Dya didn't seem to participate in the interaction.

Meeting 2.

The second meeting was held the following day. This meeting is still the same as discussing the effects of Earth's rotation and revolution. However, according to the lesson plan, the teacher will invite students to think about solutions to the solar eclipse's impact. The teacher presents the problem in the worksheet, and then the teacher asks for the solution directly in front of the class so that the students in the group do not find the solution on their own. The solution set in class is to make eclipse glasses whose design and manufacture will be handed to students in group discussions.

Students are no longer awkward and silent when the camera is placed in front of group 6. Many interactions occur between Bim, Wan, Dya, and Fia. Ray at this meeting did not leave because of illness, and Ray was not included in the discussion analysis because he did not participate in STEM-integrated science learning until the end. However, despite no Ray, the group discussion continued with much interaction. Bim, in this meeting, played a significant role in sharing the idea of the shape of glasses (20) and directing and guiding his group of friends (25, 33, 35).

20 *Bim: "eh eh (thinking) uh uh, just round this one" (points the purple mica to the eye)*

...

25 *Bim: "Yes, it will be tied later. I will do it later; make a frame first."*

26 *Wan: "What is the design like?"*

27 *Bim: "This is printed first." (while placing round tape into Wan's book)*

28 *Wan: " Is this printed inside or outside?"*

29 *Bim: " Outside, if inside, it will be small for the eyes. "*

In the conversation above, Wan was seen playing a role in designing and making glasses. Although Bim revealed that he didn't participate in Wan's design, observations show that at the beginning, he designed with a round lens Bim gave directions. Wan was initially confused about how to design the eclipse glasses to be made. Then Bim suggested printing a round sol as the shape of the lens (27). Bim directs Wan to draw a design with the tape (27). Then Wan started to draw round lens glasses designs. However, moments later, Wan turned the design into a square lens without a friend's direction. According to the interview, Wan drew and chose the square glasses design because it was easy to cut.

"My inspiration came from glasses in 4D glasses because I have been to the cinema and used 4D glasses. Apart from being inspired by the glasses in the cinema, this design is also easy to shape, and it is easy to cut."

Dya, during the second meeting discussion, began interacting with other group friends. Even Dya gave directions to Wan (40) and gave her opinion (39). However, Dya also makes glasses under Bim's direction (37).

37 *Dya and Fia measure the lens to the frame. Dya cut the green lens under Bim's instructions.*

38 *Fia holds the lens part.*

39 *Dya: "The lens is a little too big. It does not fit." (While lined at the mica)*

40 *Dya: "Wan scissors, I want scissors, but I am afraid" (handed one glasses frame and lens to Wan)*

Fia during the second meeting was more of herself and minimal interaction with her group friends. Fia is seen helping Dya hold the green lens that will be cut (38). In addition, it was also seen that Fia followed Bim's direction to fill out the worksheet on the steps for making glasses. According to Fia, in the following interview, he only played

a role in writing the method of making, initially directed by Bim. In addition, during prototyping Fia was only observed.

"Write how to make. At first, they were directed, then the rest was written from their thoughts. Directed by Bim"

From this presentation, it can be seen that all students only understand the function of the glasses that are made without knowing the theory of how the glasses can protect the eyes from the sun.

3.2 Student Activities in Integrated Science Learning STEM Pre-Service Teachers

The study was conducted at SMP Surakata in one of the 7th-grade groups under the guidance of a pre-service science teacher who carried out STEM integrated science learning in the Solar System subject. STEM integrated science learning activities are conducted for two meetings with 2 hours of lessons or 90 minutes.

Meeting 1.

This meeting discussed the material of the Solar System using the STEM approach with a discovery learning model. The pre-service teacher divides the students into several groups. When the seats for the group were determined, Vin, Ari, Ran, Lia, and Al immediately positioned themselves and continued to work in groups. When the camera is placed in front of the seat, they are awkward at first but eventually seek attention in front of the camera.

1 *Ran: "Here you write."*
2 *Vin: pointed to his writing in the book "My writing is not good, are you sure?"*
3 *Ran: laughs "well, you think the answer is this number."*
4 *Vin: "So far, the one who does not work (pats Ari on the shoulder) is the presenter. Agree?"*
5 *Al, Lia, Ran: "Agree."*

From the dialogue above, it can be seen that Ran is building collaboration numbers 1 and 3. Ran divides the task to Vin to fill the worksheet section even though Vin explicitly refuses but Ran still orders Vin to think of answers. At the first meeting, Ran also seemed to be drawing glasses designs. Initially, Ran drew without anyone's direction, but on several occasions, Lia and Al tried to give suggestions for Ran's design.

6 *Al:" uh, do not be too close to this."……..*
8 *Al:" this one is a bit wide."*
9 *Lia: "It is a bit here" (pointing to the glasses design)*

Lia is seen advising Ran (9). However, Ran looked confused and finally gave the worksheet to Lia. Lia's contribution stopped at the first meeting, and the rest Lia just observed. As for Al, apart from his role in directing Ran's design (6 and 8), he also shared his ideas by writing worksheets about the steps to make glasses. In this first meeting, Ari became a student who talked a lot outside of the subject and made his group of friends laugh.

Meeting 2.

Meeting two is filled with activities to change the design into a model or prototype. At the beginning of the lesson, the pre-service teacher gave a little direction, after which the manufacturing process was handed over to each group. In group 1, Ran rushed to make a model of the eyeglass frame on the cover paper and cut it out. At this meeting, Ran significantly contributed to directing her group members so that the work could be completed.

12 Ran: "Ri, you cut the lens, please."

13 Ari: "yes"(Then Ari cut the green lens following the pattern of the X-ray paper lens)

Ran's contribution to his friends can be seen from the above observations. Ran directs Ari to cut lens (12). Ran also seems to handle Al's work filling out the worksheet. In addition, when Ran had trouble punching holes in the rubber holder, Ran ordered Lia to take over her job while Ran continued to make the next glasses. Ran's significant role was also supported by interviews with pre-service teachers, who repeatedly mentioned that Ran had a leading role in the group.

"Ran who seems to be more involved/…/ The one who plays a role in leading is Ran."

Lia, Vin, Ari, and Al worked under Ran's direction at this meeting. During the observations, only a few discussions discussed project problems, and most of the five students' discussions spoke outside the science topic.

4 Discussion

4.1 Forms of Student Participation in STEM integrated science learning

The form of student participation in STEM integrated science learning in group 6 grade 7 at SMP Surakarta is grouped into 2, namely participation as engineers and technicians [16]. In the in-service teacher training, of the four students analyzed, there was only one student whose participation as an engineer was Bim. The characteristics of participation as an engineer [16] that emerged during the observation and interviews were characterized by this learning about how the material was taught, what the problem was, and how to solve it, carrying out system design, as shown in the results. Although Wan made the final design, Bim had a role in inspiring Wan by suggesting the initial design of round lens glasses. Another feature mentioned is to test the performance of whether the glasses can be used or not. The last characteristic that most dominates Bim's participation as an engineer is guiding his group mates. There are many opportunities that Bim sees directing his friends; even Wan, Dya, and Fia sometimes ask for Bim's opinion. On the other hand, the science teacher who was in charge of learning when interviewed also stated that the teacher who played the most role in the group and interpreted the results the best was Bim.

Wan and Dya's participation was dominated by participation as technicians, although on several occasions, they were seen as engineers, especially Wan, who played a role in making designs. However, during their studies, Wan and Dya tend to become technicians. The characteristics of participation as a technician [16] that appear in Wan and Dya involve making eyeglasses construction, following the directions of other friends, correcting errors such as poor adhesive tape, and learning about tools. Fia's participa-

tion as a true technician. The characteristics of participation as an engineer did not appear in Fia at all. Even the characteristics of participation as a technician [16] only appeared two characteristics: involvement in construction, correcting technical errors, and understanding at the functional level. Fia's interaction in this learning series is also minimal. Fia is mostly silent during the lesson and rarely conveys her ideas. Not much different from student participation in in-service teachers, from 5 students, only one student whose participation as an engineer is Ran. Ran looks like dominating and leading the group. Meanwhile, his four friends Lia, Al, Vin, and Ari participated as technicians following Ran's direction.

Uniquely from the group of students in the in-service and pre-service teachers, the engineers' Bim and Ran had the highest cognitive scores among their friends. Meanwhile, Fia and Ari, the true technicians, had the lowest cognitive scores. During the observation, it was seen that Fia only interacted a few times and had difficulty conveying her ideas. Even when interviewed when asked how she concluded the test results, Fia immediately answered that she did not know. Several occasions also showed Fia looking down. This result is presumably due to Fia's lack of confidence. Students with a high level of self-confidence have a high level of interpersonal communication [21]. This interpersonal communication will facilitate the delivery of ideas and ideas and interactions with group friends. However, in contrast, Ari talks a lot in his group but is not interested in learning matters.

The interaction between high-ability students (high midterm exam scores) and low-ability students (low midterm exam scores) is like the interaction between "teacher-students." This data is shown on many occasions Bim and Ran are seen directing and checking the work of their friends. Fia, Dya, Wan, Vin Ari, Lia, and Al were also seen asking Bim and Ran for their opinions when they came up with ideas or were about to do work. If Bim and Ran agree, then the idea will be used. This data illustration is consistent with a study on collaborative group work, concluding that in heterogeneous groups, interactions between high and low-ability students often take on the role of "teacher-student" [22]. Therefore, the role of "teacher" played by Bim and Ran made their participation as engineers stronger.

On the other hand, it weakens the participation of their group mates, which only revolves around participation as a technician and cannot develop their participation. High learning activities show high motivation and allow students to master the material better to achieve better learning outcomes [23]. This can be seen in Bim, who, in in-service teacher interviews, argues that Bim is the most active in her group. This many Bim activities show high learning motivation. Meanwhile, Fia's lack of learning activities makes Fia have low learning motivation. Fia's low motivation to learn is also due to the lack of attention from the teacher. In the group taught by the pre-service teacher, the most active in learning was Ran. This also shows that Ran has high learning motivation.

Fia's participation is also getting less and less due to the absence of attention from the teacher. The in-service teacher's attention was only centered on Bim, as in the observation, the teacher called Bim and Dya encouraged him to make glasses quickly. The in-service teacher rarely calls or approaches Fia; this is one of the reasons why

Fia's motivation to study seems lacking. This is in line with research that teacher attention has a significant effect on student learning motivation; the higher the teacher's attention, the higher the student's motivation [24], [25]. However, in Ari's case, instead of being silent, Ari tried to be noisy and noisy himself, speaking loudly not about lessons to attract the attention of the pre-service teacher.

The difference in participation and learning success between engineers (Bim and Ran) and technicians (Fia and Ari) shows that heterogeneous groups are not always successful in learning for each member. A study revealed that group heterogeneity is not a determining factor for student learning success but rather the quality of the group process which plays an important role because both high and low achievers can benefit when the group process is of high quality [26]. High-quality group processes include four characteristics, namely positive interdependence, individual accountability, equal participation and social skills [27]. When viewed from these characteristics, in-service teacher learning is far from being a high-quality group. This is because there is no interdependence of each group member even if all group members only depend on Bim the engineer, the lack of individual group accountability is marked by Bim the engineer and Wan the technician who takes a lot of work than Dya and Fia who are more observant and silent. Besides that, Bim was the only one who participated as an engineer, making student participation in groups unequal during learning activities and the group's social skills were still low. Bim invited Wan to discuss more because of the same gender and limited communication with Dya and Fia. In the pre-service teacher group, Ran looks like she is trying to make her friends work by ordering her group members so that the individual accountability of the group can be seen when carrying out their respective duties. This will trigger interdependence between members. Although the participation in this group was uneven because only Ran was an engineer, during observations, the social skills of this group were better than the previous group. The pre-service teacher also often reminded the group to divide up the tasks, even the pre-service teacher immediately ordered Vin, who was silent, to cut. This causes all group members to work.

4.2 Profile of Student Participation in STEM integrated science learning

The participation of students as engineers in STEM integrated science learning showed a few indicators, including characterization, system design, system performance testing, controlling or guiding technicians, and solving system problems. The traits of interpreting the results did not appear in the student's participation as engineers. This category is because students do not test their prototypes but are assisted by teachers during presentations, so students' prototype analysis is lacking. Pre-service and in-service teachers help students too much when interpreting the results; even the teacher gives answers. If students are given too much help students are not challenged to process information actively and therefore do not actively make connections with existing knowledge [28]. The interpretation of the results by students from the activity of making eclipse glasses only centered on the function of the eclipse glasses, as mentioned by the teacher. Students do not add and try to understand other scientific principles, for example, discussing the part of the lens and why it can filter light.

In observations and interviews, it can be seen that students who are taught by pre-service and in-service teachers are minimal in discussing the problem of the underlying science concept or theory. They only focus on the procedure for making glasses. This is due to the lack of pre-service and in-service teachers, the lack of teachers in checking the collaborative work of students and student guidance so that there are students who are always working and some are silent. Consistent research is that examining student collaboration through their participatory roles makes visible the processes associated with collaborative thinking on student learning tasks, not just doing procedural [29].

In addition to guiding technicians' work, other characteristics of participation as an engineer that emerged were still at a low level. This role is because there is still teacher intervention in service and pre-service to help find solutions to a problem. In addition, essential indicators of design engineer participation only appear a few times. This is because, during learning, the in-service teacher does not help facilitate reviewing the advantages and disadvantages of the first design and making another design. While the pre-service teacher, even though they have provided the worksheet to make another design, in reality, the pre-service teacher does not ask to make another design to improve the previous design. If previously students were given much help when testing the results, when reviewing the advantages and disadvantages of the first design, both in-service and pre-service teachers did not provide any assistance. This lack of help or support from teachers causes students to not process the knowledge gained in-depth so that students cannot connect with existing knowledge [28]. Students are also not confident in expressing their opinions because they are afraid of being wrong, especially during this research carried out in 7th grade of junior high school where students have not been able to carry out scientific approaches independently. This is in line with research showing that students with limited confidence in science need a lot of guidance and support before they can adopt a scientific approach independently [30].

Student participation as technicians in STEM-integrated science learning are all the characteristics mentioned by Kapon [16], namely involved in construction, where students participate in making models or prototypes with the direction of other friends, correcting technical errors such as repairing circuits that are not glued together, repairing broken circuits and moving objects that interfere with prototype work, learning how to use tools, and understanding principles at the functional level with explanations from other friends. Uniquely, it can be seen that Bim and Ran's participation as engineers is still overshadowed by their participation as technicians. This is because in the observations and interviews, the instructions for pre-service and in-service teachers are still dominated by instructions for working on the technique and construction of the eclipse glasses prototype. This study shows that teachers play an important role in determining student participation. Other similar research has also shown that teachers can play a key role in stimulating children's interest in science and establishing meaningful interactions during science-based inquiry [31]. Therefore, the role of pre-service and in-service teachers in guiding STEM-integrated science learning is important to be able to develop student participation as engineers and technicians to train students to face Society 5.0.

5 Conclusion

Based on the results and discussion, it can be concluded that the form of participation of each student in STEM integrated science learning for in-service and pre-service teachers is Bim and Ran as engineers, while Wan, Dya, Vin, Lia, Al as technicians, and Fia and Ari as true technicians. The profile of student participation in STEM integrated science learning is divided into 2, namely student participation as engineers and technicians. Student participation as engineers raises the characteristics of characterizing material, building collaboration, designing prototypes, testing prototype performance, controlling or guiding technicians, and solving system problems. Meanwhile, participation as a technician raises the characteristics of being involved in construction, correcting technical errors, learning how to use tools, and understanding principles at the functional level and carrying out directions from the engineer.

The implications of the results of this study are that there are two forms of student participation in STEM integrated science learning, namely engineers and technicians, while the practical implications of implementing integrated science learning are one way to build student participation as engineers according to 21st century student skills. Then student participation as engineers and technicians can grow the profile of Pancasila students who support the Merdeka curriculum.

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