Assembling, simulating, and recording robot videos as an effort to motivate middle school students and teachers of Science in Bengkulu Province

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ABSTRACT

The aim of this study was to determine the motivation of science teachers and students towards science after participating in the activity of assembling, simulating, and recording line follower robots as an effort to motivate middle school students and teachers towards science in Bengkulu Province. The research was done by direct practicing, where 60 students and 15 teachers of three junior high school (SMP): SMP Negeri 06 Seluma, SMP Negeri 02 Kota Bengkulu, and SMP Negeri 8 Rejang Lebong, were involved as the research subjects. The research activity concluded that the schools are ready to prepare simple electronics/robot laboratories for the three research subjects and the science teachers and students were motivated to learn science. It was seen from the score of 3.95 (scale of 1 to 5) for students, and for the science teacher, the score was 3.83 (scale of 1 to 5). The science teachers will follow up on robotics activities so that students will be interested in learning science at home and school.

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1. INTRODUCTION

The learning outcomes of the Junior High School National Examination 2017/2018 in the science subject in Bengkulu Province decreased by 2.91 from 57.15 to 54.24. This is the lowest among the four national exams held. One of the causes of this decline in numbers is that the teachers' way of teaching is not standard [1]. It causes a lack of student motivation in science; therefore it is necessary to take concrete actions that can increase students' motivation to learn science. One of the activities that can be done is by utilizing the development of communication and information technology, especially the role of robots in science learning.

The development of communication and information technology in the 21st century is very rapid, encouraging the use of multimedia tools and robotics in education to become popular. Robots are commonly used in schools even without engineering applications. This can be seen from the number of children who play using high-tech devices [2]. Accordingly, many studies have been conducted to investigate the effect of using robots on children's cognition, language, interaction, social, and moral development [3]–[6]. Another study reported that the use of robots encourages interactive learning, and children are more engaged in learning activities [7]–[9]. Recent reviews of the use of robots in education show that the challenges faced by researchers are complex. Research on robots is to identify the role of robots, types, types of learning activities, behavior, and places where learning takes place [10]. Researchers found similarities in the topics of robots used in learning, specifically: language, science, and technology. In addition, other factors that are important in the use of robots in education may have been ignored, such as the influence of design on interactions or the importance of parental perception in the successful implementation of robot projects in education [7].

Fast technological advancements have altered curriculum and educational methods. It is crucial today to nurture people who do not just use technology, but also create it. Therefore, it is important to foster in pupils an interest in learning about science, technology, engineering, and mathematics (STEM application). Many researchers argue that e-learning robot (ER) is a valuable and effective method for students to pursue a career in STEM, therefore the world of education is in dire need of technology, especially in the form of STEM. Educational robotics consists of hands-on activities and represents a powerful, engaging, and motivating tool for students as they design robots.

Rapid advances in technology have also brought about changes in curriculum and educational approaches. Nowadays, it becomes important to raise individuals who do not consume technology but produce technology. For this reason, it is necessary to create a desire in students to know about STEM. The implementation of science education learning in high school and junior high school is usually equipped with electronic skills (science of physics) which can be carried out in intra-curricular, co-curricular, extracurricular activities, or independent study at home [11], [12]. The current coronavirus disease (COVID-19) outbreak requires students to stay at home. This allows students to practice making robots at home so that student boredom can be overcome. The rapid development of science and technology causes knowledge of robotics to develop, it can be seen in the many roles of robots in meeting human needs and desires, ranging from factories, weapons, transportation, communication, security and even the world of entertainment cannot be separated from the help of robots. It can be said that nowadays humans cannot live without robots. The implementation of robotics activities can be at home or at school. In this study, the discussion focused on lectures, demonstrations, simulations, and robot videos to increase the motivation of junior high school students and teachers towards science in Bengkulu Province.

Robots are manipulators that are automatically controlled, reprogrammable, multipurpose, can be programmed in three or more axes, can be installed in place, or move for use in industrial automation applications [13]. Line follower robot is a robot that follows a trajectory in the form of straight lines, turns, and even intersections autonomously [14]. One of the uses of the line follower robot can be applied as a transporter of goods so that it can be directed to its place by crossing the trajectory line [15]. This system requires control so that the movement of the robot when it is operated can be in accordance with expectations. However, controlling the robot has a problem, that is the stability of the robot in observing the trajectory. Proportional, integrative, and derivative (PID) control and control mapping can be a solution to this problem. PID controller and mapping control can make the robot runs more responsively with high accuracy so that the robot's movement is more stable according to the terrain [16].

The line follower robot is designed to have the ability to detect lines or trajectories. Lines can be white or black, each type of line color has a background color that contrasts with the color of the line. For example, if the background color is white, the line is black. Sensors on the line follower robot are used to follow the path according to the shape and direction of the trajectory. The working scheme of the line follower robot system is illustrated in Figure 1.

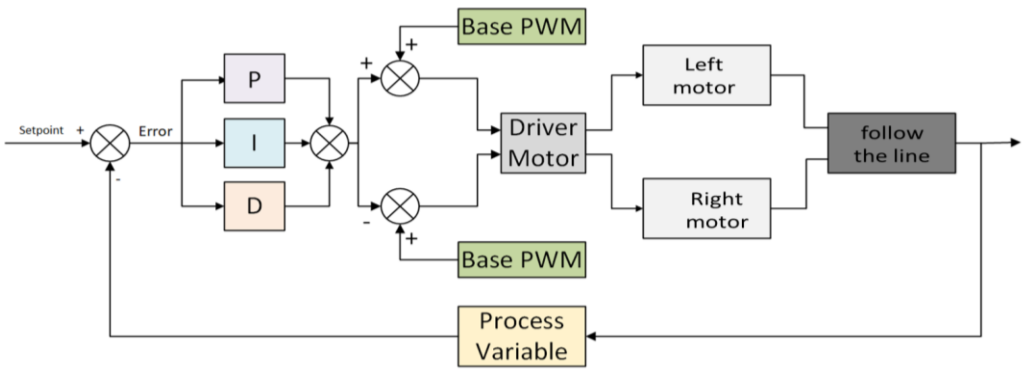

Figure 1. Line follower basic block diagram [17]

A lot of research had explore the effect of ER on STEM performance. Kandlhofer *et al.* [18] used 179 students as research subjects from nine elementary schools and found that there was no significant difference in learning outcomes of ''robot assembly and programming'' according to student gender, age, and background. The research method is in the form of a quasi-experimental design using a sample of 148 students (with an estimated age of 14.9) on the significant effect of the intervention in three subscales (mathematics and scientific inquiry, teamwork, social skills) and in two main categories (technical skills and soft skills/social aspects) found a very strong relationship significantly between the various sub-scales [19]. The results of other studies show that the use of the Nao robot is able to produce positive interactions, and children are happy to interact with the robot. For each procedure, it was further demonstrated that the children's pleasure in "playing" with the robot was maintained over time. According to the study's findings, storytelling robots are an effective way to increase kids' emotional investment in their academic pursuits. The emotional nature of the story text was reflected in the children's emotional reactions. Furthermore, the results revealed that children's IL scores were higher when they heard the Ugly Duckling story rather than the Pluto narrative [20]. Educational robotics activity with children (from 3 to 19 years) with a diagnosis of neurodevelopmental disorders. These children have the opportunity to program the behavior of the robot. Most experiences show an increase in participants' performance or abilities, engagement, and communication/interaction with peers. During the robotics session, mixed results were obtained, the important one is the need to design goals and activities for each experience carefully [21].

Another study reported Turkish high school students' attitudes towards robotics and STEM using a sample of 240 secondary school students, 98 girls, and 142 boys in grades 5 to 7. The results showed that students' attitudes toward robotics and STEM were positive. Gender has no effect on STEM attitudes. However, in terms of robotics attitude, female students were significantly less interested and confident to learn robotics than male students. The students were also significantly more likely to play with their own designed robot [22]. The application of the Spiderino swarm robot platform through workshops in class, will evaluate the effect of the workshop on students personally and increase their interest in STEM subjects especially computer science, through students' quantitative approach instruments and teachers' qualitative approaches. The results show the overwhelming acceptance of using the robot swarm platform as an effective educational tool, easy to use, entertaining, and increasing motivation to complete tasks during the observation of interactions between students and robots [23]. Edu-robotics and task-centered STEM learning are the subject of research using both quantitative and qualitative data sources. Theoretically, this study expands the use of the TCL method, which is based on the theory of mastery learning, to guide STEM learning in edu-robotics. This research can practically assist educators and students in comprehending how to conduct task-centered STEM teaching and learning activities in edu-robotics [24].

Researchers are challenged to conduct similar research in Bengkulu province. This is supported by the knowledge that researchers have in the fields of electrical, computer, and informatics engineering. The titles of this research are "Assembling, simulating, and recording robot videos as an effort to motivate middle school science students and teachers toward science in Bengkulu Province". For this reason, the problem is formulated as whether assembling, simulating, and recording robot videos in middle schools can motivate students and teachers toward science in Bengkulu Province. In order for the problem to be answered, it is necessary to formulate the purpose of this activity to describe the motivation of students and science teachers in middle school towards science in Bengkulu province.

There are six solutions used in solving research problems. The first one is simulating robotics material through interactive lectures to teachers and students from simple robots, line follower robots, and relatively sophisticated robots (humanoid robots). Then, it is recording an analog line follower robot, a PID line follower robot, a micro line follower robot, a firefighting robot, a line maze robot, and a wall maze robot using PID. The next one is recording video and simulating the robot application consisting of inertial measurement unit (IMU) feedback, IMU testing without inference, pushing form side, pushing form back, and pushing from front and slope. The fourth step is assembling the robot and testing the robot assembled with students. The next activity is interviewing the science teachers and principals of the subject. The last one is distributing questionnaires for teachers and students to find students' and teachers' motivations toward science.

The above activities are assumed to motivate students to learn science because students can directly implement real science in robotics activities. Not only learn the theory of science, but the students also experience the application of science to the skills of assembling robots. Students are significantly more likely to play with robots that they design and build themselves, so the learning process would be fun for students, and the principle of learning by playing would be well accommodated.

2. METHOD

2.1. Research types and methods

This research includes descriptive quantitative research. The method uses direct field experiments using a sample of three junior high schools (SMP) in Bengkulu Province, which are SMP Negeri 06 Seluma, SMP Negeri 02 Kota Bengkulu, and SMP Negeri 8 Rejang Lebong by involving 3 classes of 60 students and 15 teachers. The experimental activities include interactive lectures, simulations and videos, robot application video and simulation, assembling the robot, and giving questionnaires.

Interactive lectures were conducted by teachers to the students about robotics material from the simplest robots (line follower robots) to relatively sophisticated robots (humanoid robots). This lecture is interactive multimedia equipped with animation, visualization, simulation, and video. The material presented aims to broaden the knowledge of teachers and students about the importance of the role of robots in increasing students' interest in learning science. The lecture material includes the understanding of robots, robot composition, robot components, how robots work, how to make robots, robots for education, robots for entertainment, robots for defense, robots for health, robots for industry, and robots for environmental sustainability.

In the simulations and videos for the demo, the robots consist of an analog line follower, a PID line follower, a micro line follower, firefighting, a line maze, and a wall maze using PID. Robot application video and simulation consists of IMU feedback, IMU testing without inference, pushing form side, pushing form back, pushing form front and slope.

The next step is assembling the robot with six stages: i) gathering students and explaining the components of the robot and its functions; ii) explaining the tools and materials needed to assemble the robot; iii) making a path that the robot will pass; iv) assembling the robot; v) testing the assembled robot; and vi) repairing the assembled robot and explaining why the error occurred. Finally, the questionnaires were given to students and teachers in order to obtain data about the motivation of students and teachers towards this research activity.

2.2. Instrument

There are three instruments used in this activity. The first one is an interview, which is to find out the teacher's response to the activities of assembling, simulating, and recording robot videos for middle school students and science teachers to science in Bengkulu Province. Interviews were conducted with the teachers and principals. Then, the questionnaire is used to determine the students' and teachers' learning motivation toward science after assembling, simulating, and showing video robots to students and teachers in subject schools. For the data processing, the criteria used are shown in Table 1 [25], while the determination of the category of student and teacher motivation towards science is used in Table 2.

Table 1. Scores from student choices

No.	Option	Score
1	If you strongly disagree	1
2	If you disagree	2
3	If you quite agree	3
4	If you agree	4
5	If you strongly agree	5

Table 2. Categories of student motivation based on scores

No.	Category motivation Score	Score
1	Very not motivated	≤ 1,4
2	Not motivated	1,5–2,4
3	Motivated enough	2,5–3,4
4	Motivated	3,5–4,4
5	Very motivated	≥ 4,5

3. RESULTS AND DISCUSSION

The research problem is whether assembling, simulating, and recording robot videos in middle schools can motivate students and teachers toward science in Bengkulu Province. The solution carried out activities with the following algorithm: i) simulating robotics material through interactive lectures to teachers and students from simple robots (line follower robots) to relatively sophisticated robots (humanoid robots); ii) recording video of analog line follower robot, PID line follower robot, micro line follower robot, firefighting robot, line maze robot, and wall maze robot using PID; iii) simulating robot application consisting of IMU feedback, IMU testing without inference, pushing form side, pushing form back, pushing form front and slope; iv) assembling and testing robot assembled with students.

3.1. Interactive lectures

Interactive lectures were conducted with teachers and students about robotics material from the simplest robot (line follower robot) to the relatively sophisticated robots (humanoid robot). This lecture is interactive multimedia equipped with animation, visualization, simulation, and video. The material presented aims to broaden the knowledge of teachers and students about the importance of the role of robots in increasing students' interest in learning science. Lecture material includes the understanding of robots, robot composition, robot components, how robot work, how to make robots, robots for education, robots for entertainment, robots for defense, robots for health, robots for industry, and robots for environmental sustainability. The lecture material is shown in Figure 2.

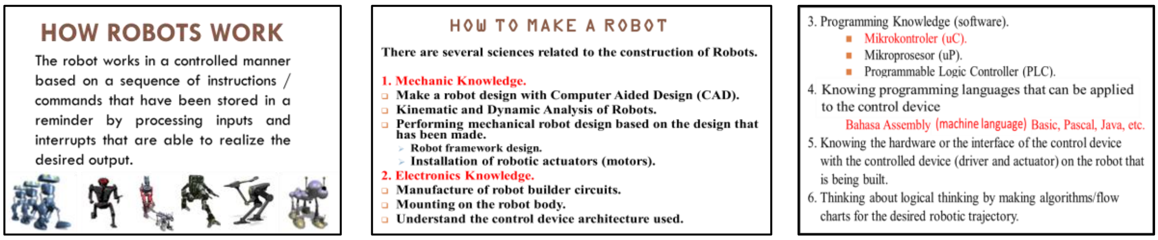

Figure 2. Sample lecture material about how robots work and how to make a robot

3.2. Simulations and videos

Demo robot activities consist of an analog line follower robot, PID line follower robot, micro line follower robot, firefighting robot, line maze robot, and wall maze robot using PID. The firefighting and line maze robots are shown in Figures 3 and 4. The simulations of the effect of pressure in both right and left side can be seen in Figures 5 and 6.

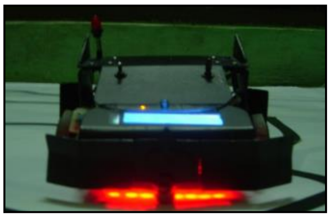

Figure 3. Firefighting robot

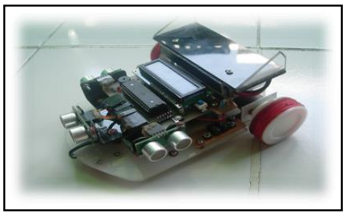

Figure 4. Line maze robot

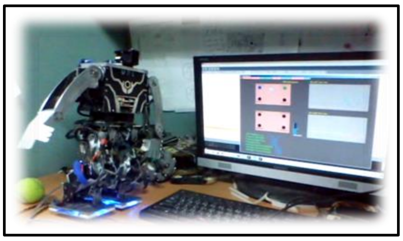

Figure 5. Simulation of the effect of pressure on the right side of the robot [14]

Figure 6. Simulation of the effect of pressure on the left side of the robot [14]

3.3. Video and simulation apps

For video playback activities and robot application simulation, it consists of seven components. They are IMU feedback, IMU testing without inference, pushing from the side, pushing from the back, pushing from the front, uneven terrain, and slope. The process is shown in Figures 7 and 8.

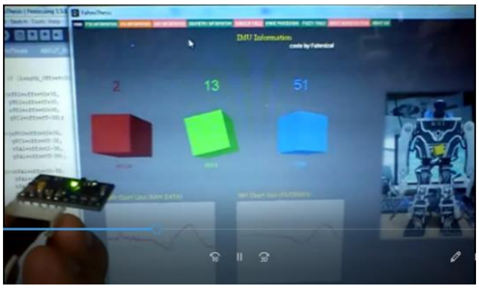

Figure 7. IMU testing without inference [14]

Figure 8. Uneven terrain simulation [14]

3.4. Assembling robot

For robot assembly activities, the following algorithm is carried out: i) gathering students and explaining the components of the robot and its functions, ii) explaining the tools and materials needed to assemble the robot, iii) making a path that the robot will pass, iv) assemble the robot, v) testing the assembled robot, and vi) repairing the assembled robot and explaining why the error occurred. These activities are shown in Figure 9. Then, the questionnaires are given to students and teachers to obtain data on student and teacher motivation after carrying out this research activity, as shown in Figures 10 and 11.


Assembling the robot


Robot's track

Submitting and documenting robot

Figure 9. Students are assembling robots, testing robots, and handing over robots at SMP N 6 Seluma


Explaining the robot's material to the students


Directing on filling out questionnaires


Students filling out questionnaires

Figure 10. Research activities at SMP N 2 Bengkulu City


Research subjects


Explaining of robot material


Filling out research questionnaires

Figure 11. Research activities at SMP N 8 Rejang Lebong

3.5. Giving a questionnaire

The teacher's response to this activity was found through interviews with teachers and school principals. Meanwhile, the motivation of students and teachers towards science after this activity, especially after seeing the demo and robot simulation, is shown in Tables 3 and 4. Based on the data in Table 3, it is obtained that; lectures, demos, simulations, and interactive videos using robotics can motivate students in the motivated category with a score of 3.95 (scale 1–5). Meanwhile, based on Table 4, it is found that; science teachers are motivated with a score of 3.83 (scale 1–5) and will follow up on this robotics activity in the future so that students are interested in learning science at home and at school.

Table 3. Recapitulation of science motivation scores for science teachers

No.	Score
1	4.45
2	3.25
3	2.85
4	3.95
5	3.80
6	2.85
7	4.15
8	4.05
9	4.00
10	3.90
11	4.00
12	3.90
13	4.60
14	3.80
15	3.95
Sum	57.5
Average	3.83
ST Dev	0.49

Table 4. Recapitulation of students' science motivation scores

No.	Score	No.	Score	No.	Score
1	3.35	21	2.85	41	4.15
2	3.25	22	4.15	42	4.05
3	2.85	23	4.05	43	4.00
4	2.95	24	4.00	44	3.90
5	2.85	25	3.90	45	4.60
6	4.20	26	4.60	46	3.80
7	4.25	27	3.80	47	3.95
8	3.95	28	3.95	48	4.15
9	2.95	29	4.15	49	4.05
10	4.15	30	4.05	50	4.00
11	4.05	31	4.00	51	3.90
12	4.00	32	3.90	52	4.60
13	3.90	33	4.60	53	3.80
14	4.60	34	3.80	54	3.95
15	3.80	35	3.95	55	4.15
16	3.95	36	4.15	56	4.15
17	4.15	37	4.15	57	4.05
18	4.05	38	4.05	58	4.00
19	4.00	39	4.00	59	3.90
20	3.90	40	3.90	60	4.60
Sum					236.9
Average					3.95
ST Dev					0.40

The activities carried out in this robot research are relatively new, previous researchers have never done it, let alone research on robotics activities in schools that aim to increase the motivation of teachers and junior high school students towards science in Bengkulu Province, this was revealed from researcher interviews with teachers and principals at schools. subject. In the implementation of this research, a series of technical activities were carried out on the research subject with the following stages: i) researchers explained the working principles and functions of electronic components in robots scientifically so that the application of science can be seen in real life and can motivate students to learn science; ii) students under the guidance of researchers and instructors assembled robots; iii) students conducted robot motion trials on the track that had been prepared; iv) students evaluated the movement of the robot on the track; and v) the researchers, instructors, and students revised the series of robots both hardware and software used to produce more accurate robot movements both in speed and accuracy of movement.

This finding is in line with other findings, such as research that show an increase in knowledge in diabetic children who use robots compared to those who do not use robots as a control group. The results of this study indicate that robots are more fun, improve results, and are more motivated. Audio/video recordings show that in terms of engagement, children with robots are more serious, more social, and more positive [26]. Robot as a very important tool in production automation has both advantages and disadvantages. Students' insight into the world of robots is getting better starting with conventional industrial robots, cooperative robots through different moving robots to humanoid robots [27].

Robotics researchers on Mars [28], with guidance criteria and with pending feedback; without guidance and with immediate feedback; with guidance and with immediate feedback; without guidance and with delayed feedback results show a significant positive impact of using delayed feedback on the communication and technology "analysis" dimension. In this case, the delay makes sense because it naturally falls within the challenges of having a robot on Mars. This study discusses four recommendations, namely the exploration of classroom-based interventions, computational practice, and computing perspective, the programming process, and qualitative data analysis. In particular, the results on delayed feedback help address their recommendations regarding the development of the computational perspective dimensions of communication and technology. Consequently, it is also necessary to discuss recommendations for clarity on the factors that may influence the acquisition of communication and technology. From this research, it was found that robots really help students' interactivity and interest in learning in class. In the case of engineering courses in the master's program, we describe the course's recent evolution to its current structure. Our inclination is to structure laboratory exercises and lecture material in a way that strikes the correct mix between conventional and cutting-edge inductive teaching and learning approaches. We discuss the incorporation of several inductive teaching approaches into courses, including competition challenges, individual projects, multi-team projects, and simulation challenges. Some sample projects from the course are given [29].

Yu and da Silva [30] compared online workshops with onsite workshops. The results showed that online workshops did not only open up opportunities for participants to get to know robotic systems in contexts without access to physical laboratories, but also allowed participants to explore the challenges and limitations of systems, and new struggles for material handling by robots can be found. These findings reflect the achievement of learning objectives, and also provide new insights worthy of consideration in design studies for robot assembly. The results of the onsite workshop showed that all groups focus on designing tools for assembling robots. It seems that the lack of access to laboratory facilities and resources forced them to focus on redesigning the toy car, which is fully in line with the learning objectives. The value of supporting tools appeared in the testing phase, which is not feasible in this online setting, but product redesigns can be presented in digital format. Online groups also have better utilization of digital tools. In addition, more participants can attend online workshops simultaneously, while the number of participants for onsite workshops depends on their physical condition. Generally, for workshops that require access to a robotic system, the number of participants is limited. In addition, the remote operation of robotic systems via only one camera poses challenges in practice. Playing the part of a robot can help discover how a robotic system works, but it cannot take the place of actually controlling a robot. In conclusion, this study offers a novel strategy for creating an online workshop on DRFA without the need for access to lab equipment. Lessons can be applied to both pandemics and post-pandemics because there are no physical limitations on participation.

Xia and Zhong [31] showed several advantages of learning with an e-learning robot (RE) and measurement instruments found in 22 papers: i) observation, ii) questionnaire, iii) evaluation of artifacts, iv) verbal interview, v) tests/examinations, vi) neuropsychological test batteries and vii) personal reports. Generally, most studies used more than one method for evaluation. As both of these approaches were still in the early stages of RE research, there is clearly a need to conduct comprehensive experiments adopting them in the future. Likewise, the performance of a group of students working with a swarm robot to program collective behavior that achieves a common goal. Features such as low cost, customization possibilities, and ease of use make it a perfect fit for schools. Research using the Spiderino platform gives students the opportunity to learn simple programming and apply this knowledge to a large number of experiments. Its attractive appearance as a spider and its development from a toy to a robot provides high potential for Spiderino to be used as an educational tool. It was found that computational practice and computational perspective, examining the programming process, and analyzing qualitative data were recommended to be carried out by involving robots [28].

Berghe *et al.* [32] explored the extent to which children anthropomorphize social robots and found that children generally anthropomorphized robots, although there were large differences between children in the degree to which they did so. The results show that the children’s overall propensity to anthropomorphize did not change significantly after the tutoring sessions but analyzes at the item level revealed a complex pattern of change indicating a shift in the overall tendency to view robots as more mechanical while at the same time attributing more cognitive abilities. on robots. As exploratory, we found a weak but significant correlation between the children’s increased anthropomorphism and their word knowledge. Exercises on controlling manipulators that aim to increase competence in learning are carried out using the robot application control method. Because ITMO University appreciates the opportunity to see how robotic systems actually work, students include some robot applications in their undergraduate and master’s theses, because it looks more demonstrative than just a simulation. Designing new tasks and adapting them for laboratory tools can be emphasized as additional job directions [33].

Users have the option to construct, plan, and program a variety of robotics artifacts using robots with varying morphology. The constructivist approach encourages a style of learning in which teachers would not really impart knowledge but rather facilitate learning, guide work groups, and have students build on their knowledge by constructing and manipulating actual objects. Robotics, therefore, offers a special educational influence, as it is a multi-disciplinary field involving the synthesis of many technical topics, including mathematics and physics, design and innovation, electronics, computer science and programming, and psychology. The results show that the pedagogical value of robots lies in making them work, through the use or extension of knowledge to identify problems and argues that robots are highly motivating technologies because they are concrete, complex, and relate to deep human needs. As a consequence, students have the exceptional chance to address many fundamental issues head-on, such as the interactions between hardware and software, the complexity of space in terms of the memory limitations of a robot controller, and time, by building physical agents along with the code to control them. Robotics can be used to overcome complexity in terms of the speed of action decisions [34]. Other research in the field of robotics found that; a physics learning program based on feedback simulation press center stability controller walking bipedal robot, based on the NGain value of 0.82, is in the very effective category to use. Meanwhile, based on the questionnaire, it is in the effective category with a score of 4.14, on a scale of 1 to 5 [35].

4. CONCLUSION

From this research activity, it is concluded that the school will prepare simple electronics/robot laboratories for the three research subjects. It was also found that after conducting this research activity, science teachers and students were motivated to learn science, which was seen from the scores of 3.95 (scale of 1 to 5) for students and 3.83 (scale of 1 to 5) for the teachers. This robotics activity will be followed up in the future so that students are interested in learning science both at home and at school.

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