The influence of PjBL model with stem approach on global warming topic to students' creative thinking and communication skills

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Abstract. This research intends to find out the influence of PjBL with the STEM approach to students' creative thinking and communication skills along with its effect size. It is an experimental study with a quasi-experimental research design. The research data were obtained from the pretest-posttest scores and the observational results of communication skills. The results showed that the value of the correlation coefficient was r = 0.61 having a contribution of Basic Competency = 37.21%. The results of the data analysis observation sheet on the students' communication skills showed that the value of the correlation coefficient r = 0.81 having the contribution of Basic Competency = 65.61%. The results of the study concluded that the PjBL model with the STEM approach affected the students' creative thinking and communication skills.

1. Introduction

The 21st-century skills encourage each individual to possess specific skills, better known as 21st-century skills. These skills consist of several particular skills that support an individual to face the challenge of this age. The *Us based Partnership for 21st Century Skills (P21)* studied four skills, which are part of individual competencies known as *"The 4Cs" - communication, collaboration, critical thinking, and creativity* [1]. Creativity is one of the essential aspects of a person's success. Fostering and training students' creativity has been a separate agenda in the school curriculum. This is in line with the mandate of the curriculum, stating that the competency standard of SMP / MTs graduates on the skill dimension is to act creatively, productively, critically, independently, collaboratively, and communicatively[2].

The observational results on both verbal and written communication indicators to students of MTs N 4 Brebes indicated that the scores had not reached the target intended. This was shown by their lack of questioning and argumentative skills, in addition to the local language used during the learning process. The lack of achievement in the students' communication skills was also conveyed by [3] in his study, stating that the average ability of students to carry out communication skills was lacking. Such a condition is considered not to meet the demands of the 2013 curriculum, which requires students to be skilled in communicating, explaining, and finding conclusions. Moreover, the results of observations on the students' creative thinking skills at MTs N 4 Brebes showed that most students tended to be passive in the learning process, lacked the desire to find out information related to the materials being taught, and were apt to get bored when the teachers explained the materials in which

they served as a listener. This is also parallel with the research of [4] that the average pre-test of students' creative thinking skills is included in the 'less creative' category.

Project-based learning is a model centering on students and provides a meaningful learning experience for them. This experience and concept acquisition are built based on the products generated in the project-based learning process [5]. Other than PjBL, today's learning has to follow the development of the globalization era and one of the ways in by integrating *Science, Technology, Engineering,* and *Mathematics* (STEM) approach. STEM learning is an integration of Science, Technology, Engineering, and Mathematics suggested to assist the achievement of 21st-century skills. This STEM approach is considered to be able to train students' creative thinking skills [6].

The STEM, when related to the environmental issues, will result in contextual learning [7] as [8] stated that the STEM learning provides students chances to learn science, maths, and engineering in solving daily life problems. STEM learning also demands students to involve in ill-defined tasks and transforms them to be well-defined outcomes through group work [9]. STEM learning has been the main priority in solving global issues like global warming, air and water pollution, clear drinkable water, and food security [10].

Global warming is one of the topics for reviewing natural phenomena. Nevertheless, those phenomena are hardly observed directly due to the lengthy process and vast coverage area. The topic studies the causes and impacts of global warming to stimulate students to explore their thinking skills to find solutions to the challenges of complex global warming problems [11]. With this in mind, the researchers felt the need to conduct research on "The Influence of PjBL Model with STEM Approach on Global Warming Topic to Students' Creative Thinking and Communication Skills."

2. Methods

This study belongs to experimental research with the Quasi-Experimental research method and the *Nonequivalent* (*Pre-Test and Post-Test*) *Control Group Design*. The research subjects were obtained through random cluster sampling and divided into groups; experimental and control. Each group held a pretest and posttest; however, only the experimental group (A) was treated. The data collection stages included: (1) documentation, used to obtain data on the number of populations and samples, a list of student names of the sample members, student grades, and documentation of activities during the study; (2) test, used to know the students' creative thinking skills through pretest and posttest questions about global warming topic, (3) observation, used to obtain the data showing the students' state during learning through observation sheets of communication skills. The final stage of data analysis employed the homogeneity and normality test as well as the analysis of the PjBL model with a STEM approach to the students' creative thinking and communication skills through the biserial correlation test.

3. Results and Discussion

The obtained research outtakes covered: (1) research documentation; (2) the pretest and posttest results on creative thinking skills; (3) the observational results on communication skillsThe effect test of PjBL model with a STEM approach to the students' creative thinking skills

The nearly similar average of both groups' pretest scores indicated that the students in the two groups had the same initial knowledge, which categorized as 'less creative.' The experimental and control class were taught using two distinct models and approaches. The prior applied the PjBL model with a STEM approach while the latter implemented the PjBL model with a scientific approach. The assessment of both classes was carried out through a posttest. The experimental class experienced a quite significant increase in the posters, which classified as 'creative.' On the other hand, the control class' posters were categorized as 'moderately creative.' These outcomes were also strengthened by the test of the difference in the average of the experimental and control class' poster results that had been arranged in Table 1.

Table 1. The difference test between the two classes' poster

Class	Data	Ttable	tcount
Experimental Control	Poster	1.99	5.83

Table 1 shows that tcount > ttable so that the H0 was rejected, and Ha was accepted, which means that the experimental class students' creative thinking skills were higher than those in the control class in terms of poster making.

One of the objectives of this study is to reveal the influence of students' creative thinking skills after experiencing the PjBL model with a STEM approach. The posttest outcomes on creative thinking skills after receiving such learning were analyzed using the biserial correlation and resulted in a stable correlation coefficient. The data of creative thinking skills were also supported by the product, i.e., poster, made by the students in the two classes. Moreover, the difference test which was performed on the posttest and poster results indicated that tcount > ttable.

There were two most prominent aspects of creative thinking skills in this study. The first was originality, demonstrated through the practicum activity and the making of the greenhouse effect model and posters. The second aspect was elaboration, in which the students looked for a deeper meaning to the answer or a problem-solving process by taking detailed steps, developing or enriching other people's ideas, and testing the details to see the direction to be taken. This was indicated by the process of interpreting the results of practicum data and the solutions from the concept of the materials provided.

The application of the PjBL model with a STEM approach began with the reflection stage by handing out questions or problems for the students to investigate. This stage could train the students' creative thinking skills on the fluency aspect, that is, their ability to provide answers to questions submitted by the teacher and to smoothly express opinions or provide feedback. In addition, the students; flexibility was also honed when they were observing images, videos, or things around the environment related to the global warming topic. Their observation would provide various interpretations of what they have watched or seen. The knowledge obtained by the students at this stage as part of the science aspects arose in learning. This is in line with what was conveyed by [8] that STEM learning needs to emphasize several aspects in the learning process, including asking questions and building explanations.

The next learning phase was *research* on how to use technology and engineering, namely compiling / designing projects based on the materials being studied. This is following [8] that STEM learning needs to emphasize aspects of information technology and computer, computational thinking, and solution design (engineering). The students gathered information and made plans for the project design. Planning was done collaboratively between the teacher and students and included preparing tools and materials being used, integrating materials, and preparing project implementation schedules. This stage has practiced the students to think about *elaboration*, which is to develop ideas conveyed by others through the information sources they got, especially in developing project design.

Further, the discovery stage emphasized the *engineering* field during the product manufacturing process. At this phase, the students not only be able to design but also define problems through the products they made [8]. The students built and developed their abilities during the product making process; besides, it also encouraged them to think flexibly-a variety of different ways to complete the project they made and classified things according to different categories. This can be seen from the project results obtained between the different groups according to their respective creativity.

Meanwhile, the application stage implemented the maths field that is the ability to manage the observational data. This is parallel with [8], stating that STEM learning must apply maths skills in terms of data processing. The students tested the products that have been made through several practices to find out the influence of plants on the environment and the various causes and impacts of global warming using the products that have been made. This stage fostered the students to think

creatively on the fluency aspect in which they could quickly see the mistakes and weaknesses of an object or situation. This was evidenced when there were several groups obtained less satisfactory practical results as the students could find out the cause of the error. This is supported by the results of research by [12] elucidating that students are trained to elaborate answers by doing detailed things, such as making practicum procedures for solving problems, detailing objectives, tools and materials, experimental steps, observation tables, data analysis, and conclusions, in addition to enthusiasm in trying to find solutions to a problem.

The last learning phase is the communication of which the students presented their products and reflected on the activities and project results. They expressed their feelings and experiences while completing the project and developed ideas conveyed by others after they knew and learned the concepts as a whole. At this stage, the students engaged in a discussion based on evidence where they obtained, evaluatee, and communicate information [8]. Based on the model and approach applied in the experimental class, the students seemed more enthusiastic in learning by carrying out activities such as making greenhouse model projects, practicums to making posters compared to the control class, which only conducted discussions and poster making. This is supported by the results of research [13] revealed that the integrated STEM-integrated PjBL could increase student interest in learning as it becomes more meaningful, helps students solve problems in real life, and supports future careers. Besides, the questionnaire data analysis results in Table 4.4 also showed a positive thing, which generally students felt that learning science using PjBL integrated with the STEM approach was more interesting, increasing their interest in learning and fostering students' creative ideas.

3.1. The Effect Test of PjBL Model Integrated with STEM Approach to Student Communication Skills

The correlation analysis results of the PjBL model integrated with the STEM approach effect on global warming topic to student communication skills based on observational data are presented in Table 2.

Table 2. The Correlation Analysis Results of the PjBL model integrated with STEM approach towards Student Communication Skills

Type of Data	r	t_{table}	T_{count}	Basic Competency (%)	Information
Experimental Control	0.81	1.99	10.25	65.61%	Very strong

Table 2 informs that the coefficient correlation (r) was 0.81, and the basic competency was 65.61%. These results showed that there was a convincing correlation between integrated science learning and the PjBL model with a STEM approach to student communication skills. The table also indicated that the tcount > ttable so that the H0 was rejected, and Ha was accepted. This means that there was a significant difference between the final observational results, in which the experimental class students' communication skills were better than those in the control class. These results appear in the following figures 1 and 2. The scores were obtained from four-time observations on oral and written communication skills.

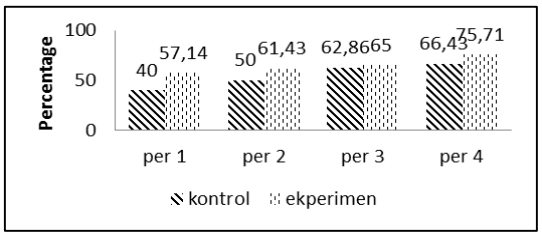

Figure 1. The Observation Results of Oral Communication Skills

Figure 1 explains that verbal communication skills in the experimental and the control class for four-time observations were dynamic. The oral communication skills of students in the experimental class were always higher than the control class students. On the other hand, the verbal communication skills of students in the experimental class increased from the beginning to the end of the meeting, namely at the first and second meetings which included in the 'moderate' category, while for the third and fourth meetings included in the 'good' category. The percentage of verbal communication in the control class also increased at each meeting, namely, at the first meeting that was classified in the 'poor' category. The second meeting achieved the 'moderate' category, and the third meeting was included in the 'good' category. The highest communication skill results of the experimental and control class were obtained at the fourth observation, where the experimental class remained to score higher than the control class.

The next observation results are the students' written communication skills during the four observations in the two classes presented in Figure 2 below:

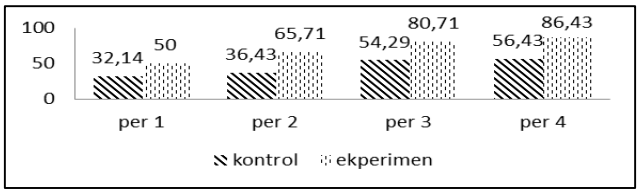

Figure 2. The Observation Results of Writing Communication Skills

Figure 2 shows the practical written communication skills in the experimental and the control class for four observations. The written communication skills of students in the experimental class were always higher than the control class. The first meeting of the experimental skills was included in the 'moderate' category; the second meeting achieved the 'good' category while the third and fourth meetings respectively classified in the 'excellent' category. Contrarily, the achievement of the control class students at the first and second observations was in the 'poor' category, while the third and fourth observations were in the 'moderate' category. At last, the students' written communication skills in the experimental and control class got the highest percentage at the fourth meeting.

The observational data resulted in a robust correlation coefficient. The difference test was also conducted on the data using a t-test, which showed that tcount> t table. This shows the differences in the communication skills of the students in both classes in terms of oral and written communication skills.

The students' oral communication skills as measured by applying the PjBL with the STEM approach included: (1) expressing opinions, (2) clarity of sound, (3) the use of proper grammar, and (4) mastery of the topics presented. The observation of the verbal communication skills of students in the experimental class took place by applying the PjBL with the STEM approach. The first learning phase was a reflection, of which the learning began with giving questions or problems to students to investigate. The experimental class students began to interact with their groups to develop project designs based on the constraints provided on the student worksheet. Then, the students submitted proposals related to tools and materials and concepts used for project development. Following the opinion of [14], PjBL increases children's social sensitivity and ability to the 21st-century skills, including communication skills by being a good listener and negotiating in making decisions and respecting friends when sharing ideas in teams. At this stage, the students' ability to express opinions is assessable by the teacher.

In the research phase, the students looked for related information needed to do a project by asking the teacher and equipped with information from the internet. The next step was discovery and application, where the students compiled and obtained observational data from projects that have been made. The last stage was communication, in which the teacher can measure the students' verbal

communication through presentations. The aspect assessed included sound clarity, the use of proper grammar, and mastery of the topics delivered. Similarly, [15] elucidated that in presentation activities there are several indicators of oral communication that can be measured, namely conveying or expressing opinions and ideas in a logical sequence, fluency in expressing opinions, the loudness of voice, making eye contact with the audience, and mastery of the topic. This is supported by the opinion of [16], which states that oral communication skills are trained by way of presentation. Verbal communication, such as through presentations, can train students to convey what they have received directly using language that is easily understood by the teacher and other students.

The distinct percentage of verbal communication between the control and experimental class at each meeting happened due to the need for verbal communication. The experimental students' communication skills kept developing not only during the discussion and doing worksheets but also in project making. They were enthusiastic about joining the activities, and many of them proposed questions by trying using the proper language. This is supported by [17], stating that project-based learning allows students to get the expected benefits, and one of them is the chance for the students to build communication skills.

The next communication skills were the written one, which consisted of several indicators: (1) information writing, (2) figure making, (3) graph/table making; (4) conclusion making — the observation of the communication skills of the experimental class students. The observation of the written communication lasted during the learning process. The first learning stage was a reflection of which it began with the giving of the question to the students to investigate. The students wrote information obtained related to the literature provided on the sheets. At this stage, the teacher could measure the aspect of written communication skill appeared; the obtained information writing.

The research phase enabled the students to look for information required in the project making by asking the teacher and browsing from the internet. Every group searched for references of project design that would be used then they drew the selected design on the sheet provided. The design turned out to be different, and this showed various ideas in arranging the respective project. The design was poured into a mini proposal. Besides, they were also asked to write a report of each activity that contained a conclusion following the research objective. The measured written communication aspect was picture and conclusion making.

The next step was the discovery and application. The students obtained and compiled the observational data using the projects they have made. The aspect assessed included the ability to writing the observational results in the form of tables/graphs. Nevertheless, the students found it challenging to arrange the observational data at the first meeting so that only 50% of the results were obtained and categorized as 'intermediate.' At the next meeting with different practicum, the students began to show an increase in behavior by 86.43% and classified as 'excellent.' They showed responsive attitudes towards making projects and practicums such as preparing the roof of the greenhouse effect model deftly, observing changes that occurred during the practicum, and writing the observations in the table, compiling a diagram in accordance with the data obtained then report writing. According to the research of [18], the students' written communication skills were assessed from observational reports written after conducting practical activities as it could help them develop themselves in solving problems faced by the students in the context of science.

The last learning phase is communication, where the students conveyed the results of the products; the greenhouse effect model and global warming poster. [19] explained that when they were doing the project assignments, the communication skills of students were indirectly trained. Apart from that, the student communication skills were also exercised when they conveyed the project results through presentations, even more so when they were requested to write reports on project development.

The results of these positive responses were based on learning experiences on the global warming topic. The learnings have given the students new experiences starting from designing projects, doing practicums, formulating observations, and delivering them according to concepts they have learned directly. This is considered very influential in training and improving their communication skills as well as foster their creative ideas through project making.

4. Conclusion

The application of the PjBL model with a STEM approach on the global warming topic affected the students' creative thinking and communication skills in a 'strong' and 'very strong' category with a contribution score of 37.21%. Moreover, the learning has also contributed to the students' communication skills with 62.41% coefficient of determination. The application of the PjBL model with the STEM approach had a positive impact on the students' creative thinking and communication skills, such as generating students' creative ideas through projects on the global warming topic, practicing student communication skills during presentations, and making reports. The application of the STEM learning approach should be considered in the world of education, especially in our country, as it could train students at any level to gain skills in the fields of science, technology, engineering, and mathematics to compete with capabilities the globalization era.

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