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Biotechnology Engineering Vertical Hydroponic Farming in PjBL-STEM Learning Jigsaw Strategy to Improve Creative Thinking Skills and Creativity of Grade 10 Students

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Abstract: This study tested the effectiveness of PjBL-STEM learning model jigsaw strategy on creative thinking skills and creativity of grade X students on biotechnology vertical hydroponic farming material. The research method used was quasi-experimental design with pretest-posttest control group design, which was conducted in Class X SMAN 1 Ciracap in Sukabumi Regency as many as 60 students consisting of 30 experimental class students and 30 control class students. Data collection was conducted using initial and final tests for creative thinking skills and observation sheets for student creativity and student response questionnaires to the PjBL-STEM Jigsaw strategy model. Quantitative data from the study were analyzed using SPSS-25 and qualitative data were processed using descriptive analysis. The experimental class received PjBL-STEM learning treatment with jigsaw strategy, while the control class used PjBL. For the first time learning model applied in class X, PjBL-STEM jigsaw strategy is effective in improving students' creative thinking skills and creativity. The prominent creative thinking skills are shown in the fluency and originality indicators. Based on the observation, the implementation of the PjBL-STEM model of jigsaw strategy directs students to the steps of inquiry, engineering design, production process, and communication much better than PjBL.

Keywords: Creativity; Jigsaw strategy; PjBL-STEM; Vertical hydroponic farming

Introduction

Education is important for human life, because the education process prepares the birth of quality human resources. Today's 21st century education requires students to master Science and Technology (Science and Technology) which is one of the important keys in facing future challenges. The challenges include the ability to develop human resources or abilities, improve the quality of life, and equitable development. Science education plays an important role in education to prepare students who have science literacy, namely the skills of critical thinking, logical, creative thinking and initiative in responding to various kinds of issues in society caused by the impact of the development of science and technology. These abilities are in line with 21st Century skills which consist of four components: critical thinking, communication skills, collaboration, creativity (Javed et al., 2019; Joynes et al., 2019).

In fact, Indonesia as one of the countries that has entered the era of globalization is experiencing a shortage of quality human resources, which has an impact on the low quality of education in Indonesia. Learners' ability to answer application and discussion questions is still relatively low compared to comprehension questions. This can be seen from the PISA (International Student Assessment Program) results published in 2016, which showed an average score of 403 for Indonesia, compared to the international average of 500-501 (Khoiriyah et al., 2018). The low quality of education in Indonesia demands educational reforms that can improve learners' skills in basic science education, including critical thinking skills, creative thinking and creativity which are components of 21st

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century education or the industrial era 4.0 (Lestari, 2021).

Creative thinking skills are an important cognitive aspect required for meaningful learning in any field, as creative thinking skills are one of the abilities that learners must have in the 21st century (Ernawati et al., 2019). Creative thinking skills are aimed at synthesizing ideas, generating new ideas, and assessing the effectiveness of existing ideas. Creative thinking skills allow learners to generate many ideas and arguments, ask questions, recognize the truth of arguments, and even allow learners to be open and consider different perspectives (Syarifah, 2019). Creative thinking skills in science learning can provide a new perspective for learners to find answers to science problems (Yasiro et al., 2021). Activities such as observation and experimentation allow learners to learn independently, understand lessons more easily, develop a positive attitude towards science and develop their creativity. Guiding learners to think creatively is an important part of the educational process to acquire the skills they need for the 21st century.

In addition to creative thinking skills, no less important thing that must be possessed by students is the ability of creativity. As revealed by Pllana (2019) which reveals that creativity as an initial innovation step that determines the progress of education, especially accelerating overall economic growth in a society. This ability of creativity must be trained early on in students because with the ability of creativity, students are able to adapt to all challenges in the era of globalization and the industrial era 4.0. This is in line with the opinion of Ritter et al. (2020) which states that by practicing the ability of creativity students are able to contribute to their readiness when plunging into a world that continues to change very quickly.

The weak creative thinking skills and creativity of students are shown by the results of observations at one of the State Senior High Schools (SMAN) in the Ciracap Jampang Kulon area using essay test instruments, questionnaires and interviews with biology teachers and several class X students at the school, there are several problems related to the success of biology learning including: the low creative thinking skills of students, namely flexible thinking (Flexibility) 48.24%, fluent thinking (Fluency) 53.50%, original thinking (Originality) 57.89, and elaborative thinking (Elaboration) 48.68% . Meanwhile, based on the results of the analysis of students' creativity abilities based on the distribution of questionnaires, it is still in the low category, this is because learning takes place not based on real problems or problems and project-based learning is rarely carried out in the learning process.

To overcome this, the selection of learning models in the learning process is one of the success factors in achieving goals. Using the PjBL (Project-Based Learning) learning model, or project-based learning model, is one option that helps students understand the subject matter because it provides direct practice not just theory. In addition, the PjBL learning model allows learners to analyze problems, provide critical responses to problems, facilitate solutions, and make it easier for educators to deliver learning experiences to their learners. As stated by Dywan et al. (2020), Project-Based Learning (PjBL) is a learning model based on learning activities and real-world tasks (projects) that present challenges for learners.

In addition to the use of learning models that can support the success of the learning process, no less important is a creative and innovative learning approach. One of the learning approaches that teachers and educators can choose is STEM (Science, Technology, Engineering and Mathematic) learning. This STEM learning approach is expected to be able to improve students' creative thinking skills. As stated by Lestari et al. (2018) and Afriana et al. (2016), the STEM approach can improve students' creative thinking skills, adapt to the era of globalization and Industry 4.0, and become more competitive. On the other hand, Hasanah et al. (2021) suggested that the application of STEM is able to improve 21st century abilities which include Critical Thinking, Communication, Collaboration, and Creativity.

In addition to learning models and learning approaches, it is also important to have a learning strategy that allows students to be more challenged to be able to collaborate and become experts in a learning topic. The learning strategy that can be used is the jigsaw learning strategy, as stated by Berger et al. (2015) and Torabi et al. (2022) which states that through the jigsaw learning strategy, students become experts in certain learning sub-topics because in this strategy there are expert groups who will later explain to the original group about the sub-material that has been learned in their respective expert groups. The use of this jigsaw strategy is expected to be able to improve students' creative thinking skills. This is in line with the results of research conducted by Mirah et al. (2020) which revealed that the use of the jigsaw strategy was able to improve the creative thinking skills of grade XI students (Mirah et al., 2020). Based on this explanation, it can be concluded that the use of the jigsaw strategy in the learning process can improve students' creative thinking skills.

The application of the PjBL (Project Based Learning) learning model combined with the STEM (Science, Technology, Engineering and Mathematic) approach is expected to be able to improve students' creative thinking skills so that they are able to use all their abilities from formulating problems, designing, conducting trials, and concluding and communicating research results in solving problems both individually and in groups. This is in accordance with research conducted by Saefullah et al. (2021) and Sumarni et al. (2020) which reveals that the use of the PjBL-STEM model can improve students' creative thinking skills by showing the ability to provide creative ideas in solving a problem. Likewise, the results of research Baran et al. (2021) and Priatna et al. (2020) reveal that learning using the PjBL-STEM model can improve 21st century skills. The same thing was revealed by Anindayati et al. (2020) that the use of the PjBL-STEM model can improve students' mathematical creative thinking skills.

Likewise, students' creative thinking skills are expected to increase with the application of the PjBL (Project Based Learning) model combined with the STEM (Science, Technology, Engineering and Mathematic) approach. This is in accordance with research conducted by Saefullah et al. (2021) and Sumarni et al. (2020) which reveals that the use of the PjBL-STEM Jigsaw Strategy model can improve students' creative thinking skills by showing the ability to provide creative ideas in solving a problem.

Based on the search results using Publish or perish for 200 international and national journals, there is no use of the PjBL-STEM model combined with the Jigsaw strategy in the learning process. In addition, vertical hydroponic farming biology material is a biotechnology material that is being discussed and applied internationally as in developed countries today as a step to produce modern agriculture.

Based on this background, the problem is formulated as follows "How is the PjBL-STEM model on the theme of vertical hydroponic farming developed and implemented to improve students' creative thinking skills and creativity?". The problem will be answered based on the following research questions: (1) How is the learning implementation of the PjBL-STEM jigsaw strategy model?, (2) How is the increase in creative thinking skills after learning the PjBL-STEM jigsaw strategy?, (3) How is the increase in student creativity after learning the PjBL-STEM jigsaw strategy?, (4) How do teachers and students respond to the application of the PjBL-STEM jigsaw strategy model on biotechnology vertical hydropoonic farming material.

Method

Research Methods

This study examines the effectiveness of the PjBL-STEM model of the jigsaw strategy on creative thinking skills and creativity of students conducted using the Quasi Experimental Design method. This Quasi Experimental Design method has a control group, but cannot function fully to control outside variables that affect the implementation of the experiment, or more briefly a pseudo experiment (Ivinson, 2001). Whatever research design is used in this study is pretest-posttest control group design (Creswell, 2018). The research implementation time starts from October 2022 to August 2023.

Participants

In this study, the samples used were 2 classes, namely classes X-3 and X-4. Determination of the research sample was carried out by purposive sampling. Purposive sampling is a sampling technique with certain considerations (Sugiyono, 2019). The two classes were selected based on the results of the researcher's discussion with the Biology teacher who stated that the two classes had the same cognitive abilities, namely seen from the average daily score and the average UTS and UAS scores, as well as the characteristics of students in classes X-3 and X-4 were almost the same, so that students were considered to have homogeneous abilities. The selected class is class X-3 of 30 students as an experimental class that will use the Jigsaw Strategy PjBL-STEM model and class X-4 of 30 students as a control class that will use the PjBL (Project Based Learning) model.

The research procedure includes the planning stage, the implementation stage and the final stage. The planning stage includes making research instruments, the implementation stage by providing PjBL-STEM Jigsaw Strategy learning treatment in experimental classes and PjBL in control classes, while the final stage includes data analysis, discussion, and drawing research conclusions.

The instrument used is a question of creative thinking ability according to Guilford developed by Munandar which consists of 10 essay test questions. As for creativity, an observation sheet of vertical hydroponic farming product assessment was used. To strengthen this research, a questionnaire of student responses to the application of the Jigsaw PjBL-STEM Strategy and interviews with teachers regarding the use of the Jigsaw PjBL-STEM Strategy were also used. The data collection techniques used were written tests, observation sheets, and questionnaires. The items were consulted and validated by expert lecturers (judgment experts) and tested. The essay questions totaled 10 items for the knowledge aspect and the competency aspect in the context of vertical hydroponic agricultural biotechnology. While the creativity aspect uses an observation sheet to assess vertical hydroponic farming products.

The results of the validity test of the creative thinking skills essay test questions were tested using SPSS-25, namely by looking at the Pearson Correlation value on each item with a validity level of r count 0.279 with the number of respondents 50 students and all were declared valid based on the results of the calculation, which was above r count. The reliability of the creative thinking skills essay test using SPSS-25 resulted in a Cronbach's Alpha value of 0.676 which was declared reliable with a moderate category. Analysis of the improvement of creative thinking skills can be calculated using Gain Score. Gain score is the increase or difference score between the initial test score (pretest) and the final test (posttest). The calculation of the gain score can be done in the following way:

$$N - \text{gain} = \frac{\text{Skor Posttest} - \text{Skor Pretest}}{\text{Skor Ideal} - \text{Skor Pretest}} \quad (1)$$

To determine the criteria for increasing the value of students' creative thinking skills based on the criteria outlined by Hake (1999), namely g> 0.7 high category, 0.7 > g> 0.3 medium category, and g < 0.3 low category. After the average value of normalized gain for the two groups is obtained, it is then compared to see the difference in improving students' creative thinking skills in the two classes. If the average normalized gain value of a class is higher than the average gain in the other class, it can be concluded that there is a different effect of using the PjBL-STEM Jigsaw Strategy model in students' creative thinking skills compared to the PjBL model. The hypothesis test used is the t-test using the IBM SPSS Statistics version 25 application with the Kolmogorov-Smirnov test. Data is said to be normal if the sig. > 0.05 at a 5% significance level with a t-test of two independent samples. The purpose of the t-test of two variables is to compare whether the two variables are the same or different. Meanwhile, the creativity of students is measured by comparing the percentage results of product values in the experimental class with the control class.

Furthermore, a correlation test is carried out which aims to determine the relationship between creative thinking skills and student creativity using IBM SPSS-25, namely by looking at the pearson correlation value and also the significance value for alpha 0.05, if the Sig value <0.05 then it is declared correlated, but if the Sig value>0.05 then it is declared not correlated. The guidelines for the degree of correlation are 0.00 to 0.20 no correlation, 0.21 to 0.40 weak correlation, 0.41 to 0.60 moderate correlation, 0.61 to 0.80 strong correlation, and 0.81 to 1.00 perfect correlation.

Result and Discussion

Implementation of the Jigsaw Strategy PjBL-STEM Model on Biotechnology Vertical Hydroponic Farming Material

This study aims to develop a PjBL-STEM Jigsaw Strategy learning model on Biotechnology Vertical Hydroponic Farming material that can improve students' creative thinking skills and creativity. This study also examines the extent of the improvement of students' creative thinking skills by using a 10-item essay test instrument, and examines the improvement of students' creativity skills by using the Vertical Hydroponic Farming product observation sheet and also to determine the students' response to the use of the PjBL-STEM Jigsaw Strategy model.

The learning model that has been developed with the Jigsaw Strategy PjBL-STEM model syntax which includes 4 stages as proposed by Mark Windale (2022) in the workshop for Indonesian SEAMEO STEM ED, the 4 stages are: Stage 1: Introduction the problem and content (Launch project) scientific investigation, Stage 2: Developing understanding of the problem and background knowledge understanding and skills (Build knowledge), Stage 3: Solving the problem (Develop and critique, Stage 4: Communicating the solution to the problem (Present products publicly). The four stages accommodate the principles of the STEM approach, the inquiry process, EDP, prototype development and communicating the results of collaborative work. The learning stages with the syntax of the Jigsaw Strategy PjBL-STEM model are contained in the Plan The four stages of the learning process will be described as follows:

In the first stage or Stage 1: Introduction the problem and content (Launch project) scientific investigation, students observe problems through video shows about the increasing amount of land used for settlements and industries, so that agricultural land is decreasing causing many people to experience food shortages. Learners who have been divided into five original groups work together to discuss solving the problem, they look enthusiastic about each other's ideas in the discussion, then each of the five groups explains the findings based on the results of the group discussion, at the end of the discussion the teacher concludes as a whole. At this first stage, students' flexible thinking skills (Flexibility) and fluency thinking (Fluency) are needed in order to be able to solve the problems posed based on the views or ideas of each student in each group, besides that communication skills are also needed at this stage.

Figure 1. Teacher and learner discussion activities in stage 1

The next stage is Stage 2: Developing understanding of the problem and background knowledge understanding and skills (Build knowledge). In this second stage, students are able to understand the problem, explore knowledge through references to solve problems through the process of inquiry, and experimentation, the problem proposed is "Mr. Haris has open land around his house with a size of 2 x 3 meters. Mr. Haris wants to use the land to fulfill food (vegetables) for his family. How does Mr. Haris meet the family's food needs by optimizing the existing land to produce as much food (vegetables) as possible?". Learners together with the origin group discuss the steps to solve the problem, then one of the origin groups presents the results of their group discussions and other groups are invited to refute, add or strengthen.

Furthermore, students are divided into three expert groups from representatives of each origin group consisting of 10 members in each expert group. The first expert group discusses the process of making germination, the second expert group discusses nutrition, and the third group discusses making the Vertical Hydroponic Farming tower. Furthermore, students return to the original group to explain the results of the expert group discussion and make a Vertical Hydroponic Farming product design. In this second stage, the originality thinking skills and elaborative thinking skills of learners are needed in order to be able to create a Vertical Hydroponic Farming product prototype design and be able to enrich or develop an idea.

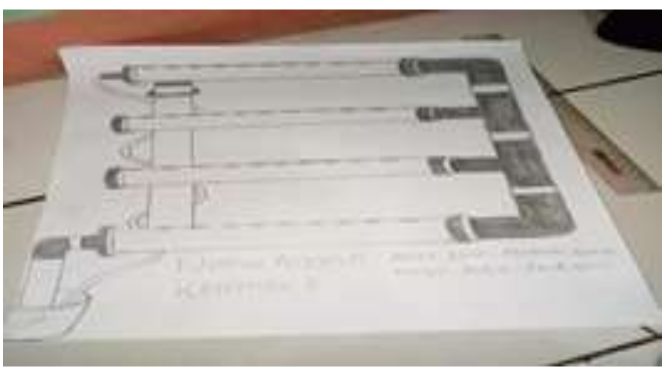

Figure 2. Learners' dsign results in stage 2

The next stage is Stage 3: Solving the problem (Develop and critique). In this third stage, learners find solutions, synthesize knowledge, think and design solutions and revise. Learners in each origin group make Vertical Hydroponic Farming tower products according to the design or design they make, assemble the germination process, organize the provision of nutrients and pay attention to the growth of plants. The process of making germination takes one week, and is followed by the process of transferring plants to the Vertical Hydroponic Farming tower, besides that at this stage providing nutrition and paying attention to plant growth lasts for one month. In this third stage, students' originality and flexibility thinking skills are needed in order to be able to create creativity skills in designing and making Vertical Hydroponic Farming tower products and be able to solve problems that occur when problems occur in Vertical Hydroponic Farming towers such as leaks in the tower so that students must try to fix it by providing special paralon adhesive glue.

Figure 3. Students' activities in assembling vertical hydroponic farming products in stage 2

The next stage is Stage 4: Communicating the solution to the problem (Present products publicly). In this fourth stage, students are able to present Vertical Hydroponic Farming projects or products, each of the original group of students presents the results of making Vertical Hydroponic Farming products and is given the opportunity to provide input to each group. At this first stage, the skills of flexible thinking (Flexibility), fluent thinking (Fluency) and elaborative thinking (Elaboration) of learners are needed in order to be able to present the results of making Vertical Hydroponic Farming products in each group of origin, besides that communication skills are also needed to.

Figure 4. Present product results

Improved Creative Thinking Skills of Learners

The results of data processing of students' creative thinking skills which became the first primary instrument or the first dependent variable were processed using IBM SPSS-25 which consisted of ten essay test questions. Data on pretest and posttest results of experimental and control classes are presented in table 1.

Table 1. Data on Pretest and Posttest Results of Improving Students' Creative Thinking Skills in Control and Experimental Classes

Class	Number of students	Highest score	Lowest Score	Average value	Sd
Pretest					
Control	30	65	24	48	10.023
Experiment	30	67	24	49	6.673
Posttest					
Control	30	74	46	61	10.669
Experiment	30	85	62	74	7.039

N-Gain Difference Test

The N-Gain test was used to see the average increase in students' creative thinking skills between the experimental and control classes. The N-Gain test was obtained from the pretest and posttest scores of the experimental and control classes.

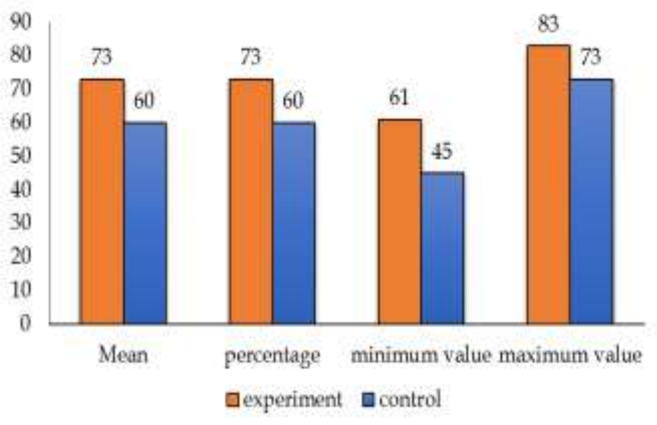

Figure 5. N-gain value of experimental class and control class

Based on figure 5 above, it is known that the results of the N-gain score test calculation show that the average N-gain score for the experimental class is 73 or 73.18% including in the high category, and for a minimum N-gain score of 61 and a maximum of 83. Meanwhile, the average N-gain score for the experimental class is 60 or 60.02% including in the medium category, and for a minimum N-gain score of 45 and a maximum of 73.

Table 2. Results of Analysis of N-Gain Value based on Aspects of Students' Creative Thinking Skills

Aspects of Creative Thinking	Average N-Gain	
	Experiment	Control
Flexible Thinking (Flexibility)	0.4	0.2
Fluency	0.4	0.2
Originality	0.6	0.3
Elaborative thinking (Elaboration)	0.4	0.3

Based on the data in table 2, it can be concluded that the use of the PjBL-STEM model jigsaw strategy is able to increase student creativity, especially in the originality thinking indicator. This can be seen from the N-gain value of the experimental class which has a higher value than the N-gain value of the control class.

Normality Test

The normality test was carried out to determine whether the initial and final test score data were normally distributed or not and also whether the experimental class and control class test scores were normally distributed or not. The normality test can be done by using the IBM SPSS Statistics version 25 application with the Kolmogorov-Smirnov and Shapiro Wilk tests. Data is said to be normal if the sig. > 0.05 at a 5% significance level. The results of the normality test calculation are presented in table 3.

Table 3. Normality Test Results for Experimental and Control Classes

Group	Significance Value	Description
Control Pre-test	0.028	Data is normally distributed
Control Post-test	0.701	Data is normally distributed
Experiment Pre-test	0.078	Data is normally distributed
Experiment Post-test	0.313	Data is normally distributed

Based on table 3, it is known that the residual value of the data is normally distributed. The calculation of the normality test can be seen in the attachment. If the data is normally distributed, it can be continued to test the significance of the difference in N-gain through the independent t-test.

Homogeneity Test

The homogeneity test is carried out if the data is normally distributed, but if not, nonparametric testing is carried out. The homogeneity test aims to determine the diversity of a variance whether homogeneous or heterogeneous. If the sig.> 0.05 then the data is homogeneous at a significance level of 5%. The results of the homogeneity test calculation obtained a significance value of Sig. 0.998> 0.0, so it can be concluded that the variance of the experimental and control class groups is homogeneous, so one of the conditions (not absolute) of the independent t-test can be fulfilled.

Hypothesis Test

Based on the prerequisite tests that have been carried out, it turns out that the data is normally distributed and homogeneous, so the hypothesis test uses parametric statistics, namely the t test, based on the results of the independent t test obtained Sig. (2 tailed) value of Sig = 0.000 <0.05 or the Sig value is smaller than the alpha value. From these data, the null hypothesis (Ho) is rejected and the research hypothesis (H1) is accepted, meaning that there is a significant difference between the experimental class and the control class. It can be concluded that the use of the STEM-based PjBL (Project Based Learning) model (Science, Technology, Engineering, and Mathematic) has a significant effect on students' creative thinking skills on Biotechnology Vertical Hydroponic Farming material.

Learner Creativity in Vertical Hydroponic Farming Learning

The results of data processing of student creativity which is the second primary instrument using the excel formula which consists of two aspects of product assessment, namely product visualization and the effectiveness of Vertical Hydroponic Farming products in this study can be seen in the table 4.

Table 4. Vertical Hydroponic Farming Product Creativity Score Percentage

Assessment Aspect	Percentage	
	Experiment	Control
Product Visualization	83.4 %	73.4 %
Product Effectiveness	91.2%	89.8 %

Based on table 4, it is known that the percentage value of creativity in each criterion has a difference in the experimental class and control class. This can be seen from the acquisition of percentage values in each criterion, namely in the product visualization criteria and product effectiveness, where the experimental class has a higher value of 88% compared to the control class of 83%.

Learners' Response to the Use of the Jigsaw Strategy PjBL-STEM Model

This analysis is used to determine the Learner's response to the PjBL-STEM Jigsaw Strategy model which is collected using the Learner questionnaire. The questionnaire used for the experimental class totaled 10 statements, consisting of 8 positive statements and 2 negative statements. The questionnaire is given after the learning is complete. The data from the results of this questionnaire analysis were then converted into a percentage of the students' questionnaire.

Based on the figure 6, in statements number one and four regarding students' interest in science, the most answers of students are agree (S) and strongly agree (SS), namely 96.7% and 3.3% answered disagree (TS). It can be assumed that students feel the importance of learning science which can later be implemented in everyday life.

In statement number three regarding the importance of mathematics in science learning, all students answered agree (S) and strongly agree (SS), namely 100%. It can be assumed that students feel that the use of mathematics in science learning is very important because it facilitates or helps in the process of solving problems presented in the learning process.

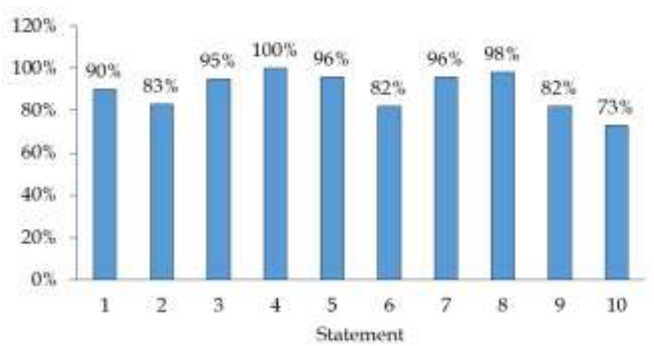

Figure 6. Percentage of student response to the jigsaw strategy PjBL-STEM model and biotechnology vertical hydroponic farming material

In statements number five, eight and ten regarding the selection of Biotechnology Vertical Hydroponic Farming material, the most students' answers were agree (S) and strongly agree (SS), namely 94.4% and 6.6% answered disagree (TS). It can be assumed that students feel that the Biotechnology Vertical Hydroponic Farming material in the learning process makes students interested in learning it because it is related to reality in the daily environment.

In statements number seven and nine regarding the use of the STEM-based PjBL model, the most students' answers were agree (S) and strongly agree (SS), namely 96.7% and 3.3% answered disagree (TS). It can be assumed that they are interested in using the Jigsaw Strategy PjBL-STEM model because they feel challenged to make their own designs to reconstruct the problems presented and also the learning model can be used for other materials.

Interview Results with Biology Subject Teacher Regarding the Jigsaw Strategy PjBL-STEM Model

The interview was conducted after the learning process was complete, this interview was conducted to find out student activeness in learning biology in general and when using the PjBL-STEM Jigsaw Strategy model. The results of the interview will be described as follows:

In general, students like learning biology, where students consider biology subjects interesting to learn because they are closely related to health and daily life. During the learning process, students often ask questions or are able to answer questions asked by the teacher or by their classmates.

Basically, biology subject teachers are already familiar with the PjBL-STEM Jigsaw Strategy teacher training model a few months back, it's just that the application of the learning model has never been implemented because they don't really understand the learning model. He also added that with the research on the use of the PjBL-STEM Jigsaw Strategy model in schools, teachers can better understand the implementation of the learning model.

The use of the PjBL-STEM Jigsaw Strategy model in the learning process makes students feel more motivated and interested in learning science, especially biology, because it makes students explore creative thinking skills more challenged to make product designs, formulate steps, and also issue creative ideas. In addition, because there is a practicum for making products, students are more visible in their creativity and collaboration.

However, there are several obstacles he expressed regarding the use of the PjBL-STEM Jigsaw Strategy model, namely; First, the use of the PjBL-STEM Jigsaw Strategy model takes quite a long time, so the material studied in one meeting is very limited. Second, the readiness of students in undergoing the learning process of the PjBL-STEM Jigsaw Strategy model is still low, because basically the PjBL-STEM Jigsaw Strategy model requires students to reconstruct their own steps to solve the problems presented. Third, because the learning requires students to produce products, sometimes we have difficulty in getting facilities for making products.

Description of Improvement in Each Aspect of Creative Thinking Skills and Creativity

As previously explained, this research aims to reveal whether or not there is an effect of the Jigsaw Strategy PjBL-STEM model on students' creative thinking skills and creativity. The research was conducted by comparing the N-Gain value in the experimental class with the N-Gain value of students in the control class after being treated for creative thinking skills. As for the creativity of students, namely by comparing the average percentage of students in the experimental class and control class.

Students in these schools are accustomed to active learning, training students to think critically and creatively, so the use of the Jigsaw Strategy PjBL-STEM model is suitable for use, because according to Elva et al. (2021) states that "The Jigsaw Strategy PjBL-STEM model is able to improve 21st century skills which include creative thinking, critical thinking, collaboration, and student communication". The teacher comes to class with a problem for students to solve, then they are given the freedom to find the best way to solve the problem". While the learning model used in the control class is the PjBL (Project Based Learning) model which is often used at the school based on the results of observations and discussions with biology subject teachers.

The experimental class in this study is a research class that gets treatment using the PjBL-STEM Jigsaw Strategy model, namely class X.3, totaling 30 students, while the control class gets PjBL learning, namely class X.4, totaling 30 students. The reason for taking the two classes as research classes is because it is seen from the average daily cognitive score of students, namely class X.3 of 78.8 and class X.4 of 78.5 and the activeness of students has a homogeneous value based on the results of discussions and observations.

Hypothesis testing to measure students' creative thinking skills is carried out using the t test calculation. As explained in the research results, the independent samples test value is obtained using Equal variances assumed with the acquisition of a value (2 tailed) of Sig = 0.000 <0.05 or a significance value smaller than the alpha value, with a confidence level of 95%. The best treatment lies in the class that has a higher average value. The experimental class obtained an average value of creative thinking skills of 73 or 73.18% including in the high category, and for the minimum N-gain score of 61 and a maximum of 83. Meanwhile, the average N-gain score for the experimental class was 60 or 60.02%, including in the medium category, and for a minimum N-gain score of 45 and a maximum of 73.

Furthermore, for the percentage results of students' creativity skills as described in the research results, the percentage value of the experimental class is higher than the control class, namely in the experimental class the average value of students' creativity skills is 88.2%, while in the experimental class the average value of students' creativity skills is 83.2%.

The results showed that the creative thinking skills of students in the experimental class using the PjBL-

STEM Jigsaw Strategy model were better than the control class using the PjBL (Project Based Learning) model. Likewise with the creativity skills of students, where the results show that students in the experimental class are superior compared to those in the control class. The four aspects of creative thinking skills in this study will be presented as follows:

The first aspect is flexible thinking (Flexibility). Flexible thinking skills or skills are a skill that must be possessed by students in order to be able to answer or solve a problem from a different point of view or have their own opinion (independently) not following the opinions of most of their friends as long as it is in accordance with the problem presented. As expressed by Irdalisa et al. (2022) which states that flexible thinking is a problem-solving skill by providing diverse answers or ideas and being able to observe each problem through different perspectives. From the results of the research collected through pretest-posttest essay questions, the results of the average N-gain value for the flexible thinking aspect in the experimental class were 0.4 including in the medium category, and the results of the average N-gain value for the flexible thinking aspect in the control class were 0.2 including in the low category. Based on this data, we can know that creative thinking skills in the aspect of flexible thinking (Flexibility) are better in experimental classes that use STEM-based PjBL models. This is in line with the opinion of Octaviyani et al. (2020) which states that the average achievement of students' creative thinking skills before and after learning PjBL-STEM Jigsaw Strategy has a significant difference. This statement is supported by the results of teacher interviews which show that students look more creative in providing ideas in solving the problems posed. In addition, this is also supported by student responses to the use of the PjBL-STEM Jigsaw Strategy model as much as 94.4% which states that they are more motivated and interested in learning science, especially for material that is directly related to daily life in global society.

The second aspect is fluency thinking. Fluent thinking skills or skills are a skill that must be possessed by students in order to be able to express ideas fluently and be able to ask various kinds of questions according to the problems presented. As revealed by Erdem et al. (2019) which states that the characteristics of creative thinking are showing potential in arguing based on facts and emotionally having the mental ability to complete tasks and responsibilities. From the results of the research collected through pretest-posttest essay questions, it was found that the average value of N-Gain for the aspect of fluent thinking in the experimental class was 0.4 including in the medium category, and the results of the average value of N-Gain for the aspect of flexible thinking in the control class were 0.2 including in the low category. Based on this data, we can know that creative thinking skills in the aspect of fluent thinking are better in experimental classes that use the STEM-based PjBL model. This is in line with the opinion Cholisoh (2019) and Marwani et al. (2020) which states that the PjBL-STEM Model is able to improve students' creative thinking skills, especially the aspects of fluency thinking with high and medium categories. This statement is supported by the response of students, which is around 96.7% who feel interested in the use of the STEM-based PjBL learning model.

The third aspect is original thinking (Originality). Original thinking skills or skills are a skill that must be possessed by students in order to be able to generate their own creative ideas or be able to create new ideas based on their own point of view based on the results of analyzing the problem. As expressed by Anindayati et al. (2020) which states that original thinking (Originality) is the skill of developing or enriching the original, not clichéd and rarely given by most people. From the results of the research collected through pretest-posttest essay questions, the results of the average N-Gain value for the original thinking aspect in the experimental class were 0.6 including in the medium category, and the results of the average N-Gain value for the flexible thinking aspect in the control class were 0.3 including in the low category. Based on this data, we can know that creative thinking skills in the aspect of original thinking are better in experimental classes that use the STEM-based PjBL model. This is in line with the opinion of Anindayati et al. (2020) which states that there is an effect of PjBL-STEM on creative thinking skills and student learning outcomes. This statement is supported by the responses of students who stated that they felt challenged to make their own designs to reconstruct the problems presented. In addition, the results of interviews with biology subject teachers also revealed that the learning process made students feel more motivated and interested in studying science, especially biology, because it made students explore creative thinking skills more challenged to make product designs, formulate steps, and also issue creative ideas.

The fourth aspect is elaborative thinking (Elaboration). Elaborative thinking skills or skills are skills that students must have in order to be able to enrich or develop other people's ideas. As revealed by Armandita (2018) which states that elaborative thinking (Elaboration) is a person's skill to enrich and develop an idea. From the results of the research collected through pretest-posttest essay questions, the results of the average N-Gain value for the elaborative thinking aspect (Elaboration) in the experimental class were 0.4 including in the medium category, and the results of the average N-Gain value for the flexible thinking aspect in the control class were 0.3 including in the low category. Based on these data we can know that creative thinking skills in the elaborative aspect (Elaboration) are better in the experimental class using the STEM-based PjBL model. This is in line with the opinion of Afriana et al. (2016) which states that students are more motivated and interested in learning science through the STEM-based PjBL model. This statement is supported by students' responses to the use of the Jigsaw Strategy PjBL-STEM model as much as 94.4% who stated that they were more motivated and interested in studying science, especially for material that is directly related to daily life in a global society. the results of teacher interviews which show that students look more active in the learning process make students feel more motivated and interested in studying science, especially biology.

Based on the N-Gain value and the percentage of creative thinking skills, the overall experimental class has a better N-Gain value and percentage than the control class. The experimental class using the PjBL-STEM Jigsaw Strategy model obtained an average (Mean) N-Gain value of 73 and a percentage of creative thinking skills of 73.18% (High). While the control class PjBL model (Project Based Learning) average value (Mean) N-Gain 60 and the percentage of creative thinking skills 60.02% (Medium).

To measure the creativity of students using the vertical hydroponic farming product assessment sheet, the percentage value of creativity in each criterion has a difference in the experimental and control classes. This can be seen from the acquisition of percentage values in each criterion, namely in the product visualization criteria and product effectiveness, where the experimental class has a higher value of 88% compared to the control class which is 83%. The four aspects of creative thinking skills in this study will be presented as follows:

The first aspect, namely product visualization which consists of five criteria, shows that in the experimental class students are superior with a percentage of 83.4%, while the control class gets a percentage of 73.4%. This is in line with the results of research conducted by Yulaikah et al. (2022) which states that the use of the PjBL-STEM Jigsaw Strategy model can increase students' creativity and concept understanding. Likewise, the results of research conducted by Hanif et al. (2019) state that the use of the PjBL-STEM Jigsaw Strategy model can increase student creativity. In this aspect, the highest value is in the product efficiency indicator where the experimental class scores 87.5% while the control class scores 51.25% and also in the product effectiveness indicator, the experimental class scores 76.25% while the control class scores 70.25%. The difference in percentage in the experimental class and control class is because in the experimental class using the STEM-based PjBL model, students are required to make a design or design of a vertical hydroponic farming tower, such as measuring in detail the distance between holes, the distance between levels of paralon, and other measurements very accurately, so that the vertical hydroponic farming tower is more sturdy or does not collapse easily when there is a shock and looks more visually appealing.

The second aspect, namely the effectiveness of the product which consists of seven criteria, shows that in the experimental class students are superior with a percentage of 91.2%, while the control class gets a percentage of 89.8%. This is in line with the results of research conducted by Meita et al. (2018) and Pratiwi et al. (Pratiwi et al., 2021) and which states that the creativity skills of students who use the PjBL-STEM model have a higher average value than the creativity of students who use the PjBL model.

The high average value (Mean) of N-Gain and the percentage of creative thinking skills and the percentage of creativity of students in the experimental class is also supported by the high average value of the percentage of student responses to the use of the PjBL-STEM Jigsaw Strategy model which is 89.5% (good), the high average value of the percentage of student responses to the use of the PjBL-STEM Jigsaw Strategy model shows that the learning model is indeed in accordance with the characteristics of students. In addition to the student response questionnaire, the instrument that supports this research is the researcher's interview with the biology subject teacher, the results of the interview show that the use of the PjBL-STEM Jigsaw Strategy model is indeed good to apply.

Both models show a very significant difference, namely the experimental class using the PjBL-STEM Jigsaw Strategy model is able to improve creative thinking skills as seen from the N-Gain value and students' creativity skills as seen from the percentage value compared to the control class using PjBL (Project Based Learning) learning. This happens because the PjBL-STEM Jigsaw Strategy model requires students to formulate their own steps for making projects, design their own projects to be made, and arrange the financing needed to complete the project, thus stimulating students to bring out their creative ideas in solving the problems posed in the learning process.

Conclusion

Based on the observation, the implementation of the PjBL-STEM model of jigsaw strategy directs students to the steps of inquiry, engineering design, production process, and communication much better than PjBL.

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Conflicts of Interest
No conflict interest.

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