Indonesian Journal of Learning and Instruction p-ISSN 2614-8250, e-ISSN 2614-5677
*Volume 7, Issue 1, April 2024* https://journal.uniku.ac.id/index.php/IJLI

# IMPROVING CRITICAL THINKING AND CREATIVITY OF BIOTECHNOLOGY STUDENTS THROUGH PJBL-STEM ONLINE PRACTICUM

**Maratus Sholikah**
*Master of Biology Education, Universitas Kuningan, Indonesia*
Email: ika899377@gmail.com

**Anna Fitri Hindriana***
*Master of Biology Education, Universitas Kuningan, Indonesia*
Email: anna@uniku.ac.id

**APA Citation:** Sholikah, M., & Hindriana, A. F. (2024). Improving critical thinking and creativity of biotechnology students through PJBL-STEM online practicum. *Indonesian Journal Learning and Instruction, 7*(1), 61-68. 10.25134/ijli.v7i1.9949

Received: 01-12-2023 Accepted: 24-02-2024 Published: 30-04-2024

**Abstract:** This study aims to enhance students' creativity and critical thinking skills using a STEM approach in online project-based Biotechnology Practicums. A quasi-experimental design was used, with 50 students divided into experimental and control groups. Data were collected via tests, questionnaires, and observations. Results showed a significant improvement in the experimental group's critical thinking ($p = 0.015$) and creativity, particularly in flexibility and originality. The conclusions of the study are: (1) The results showed a significant average difference in critical thinking skills between experimental classes and control classes after the implementation of STEM approach based on the PjBL model with classes that did not use the STEM approach based on the PjBL model in biotechnology courses in tadris Biology Department Semester 6 IAIN student Sheikh Nurjati Cirebon as evidenced by a probability value (p) of $0.015 < 0.05$. (2) Creativity of students in the experimental class of the highest indicators on flexibility and original, while the lowest indicators are on the smoothness indicator.

**Keywords:** *creativity; critical thinking skills; STEM; project-based practicum.*

## INTRODUCTON

Today the various activities of life have been dominated by technological products. Not a few of us can't live without technology. This indicates that the rapid development of science and technology is inevitable but must be faced and mastered. In the face of the era of globalization, the mastery of science and technology becomes a must. This requires various parties to be able to develop capabilities related to the development of capabilities in the field of technology, including in the field of education (Nurhikmayati, 2019). The existence of the covid 19 pandemic resulted in the learning process could not be done in schools. Learning is done at home.

Especially the practicum carried out at laboratorim MIPA IAIN Syekh Nurjati Cirebon. Because students can learn with broader technology and can be wiser in the use of communication media in online learning. But in addition to the good impact has a greater negative impact, because when practicum activities themselves at home, not done directly in the LABORATORY MIPA IAIN Syekh Nurjati Cirebon, so students experience a shortage of tools in the practicum because it is different from the completeness of practicum at home.The Covid-19 pandemic has a huge impact on the learning process, because learning that is usually carried out directly becomes online, so it is considered less effective in the process (Hilna, 2020).

Critically, these limitations will cause students to not understand the basic principles that support in lecture activities and practicums on campus, because lecturers do not directly convey what is being taught to students. So that the critical thinking skills and creativity of students become reduced. The main problem faced by IAIN students Syekh Nurjati Cirebon is the lack of MIPA laboratory facilities for students, because in the implementation of practicum at home the need for tools in practicum activities is less complete, as well as materials that will be used as trials during practicum. So that students need facilities and infrastructure that support practicum activities during the pandemic that will help practicum activities even though the implementation at home is not in the laboratory.

The implementation of practicum in mipa IAIN laboratory Syekh Nurjati Cirebon went smoothly, before the COVID-19 pandemic that existed in early March 2020. But after the COVID-19

pandemic practicum activities were carried out through online, not only in IAIN Syekh Nurjati, but almost all universities in Indonesia also experienced the same practicum implementation, namely online. So with this event, the college is looking for solutions how practicum can still be implemented even by way of online practicum at home. But in this day and age there are many ways of learning even with a long distance, because it is no wonder there are many communication information technology tools that are increasingly advanced and sophisticated.Especially with the education in the 21st century that has taught learning with technology, because technology has now become one of the keywords, in addition to globalization that is always buzzed when talking about the 21st century.

The expectations focused on learning in the 21st century must have learning and innovation skills consisting of, 1) Critical Thinking and Problem Solving, 2) Communication, 3) Collaboration, 4) Creativity and Innovation. Not only education in Indonesia that must be more varied, ranging from science, technology, engineering and mathematics (STEM), which will help students in facing the progress of today and gaining wider knowledge.

STEM learning is one of the breakthroughs for education in Indonesia that seeks to develop humans who can create an economy based on science and technology. The STEM approach is how science is integrated with technology into techniques that are all disciplines and contain elements of mathematics as the parent of science. The STEM approach invites students to become problem solvers with integrated thinking, so that it will ultimately make students able to compete in the era of free trade economy based on knowledge (Ratna, 2019).

Based on initial observations at the MIPA LABORATORY IAIN Syekh Nurjati Cirebon, during the COVID-19 pandemic is an event that is not supportive in the implementation of practicum, that in such a situation students have difficulty in carrying out practicum, perhaps due to the lack of available tools and materials to be used during practicum activities and also the lack of direct explanation conveyed by practicum assistants, So that students experience obstacles in its implementation. Researchers are challenged to use PjBL-based STEM approaches in the ongoing implementation of online practicums.

Project-based learning is a learning model that involves a product in the learning process carried out by students. Other research results also say PjBL has advantages, among others: 1) learning by finding solutions and asking questions, 2) debating ideas, 3) designing plans and communicating with others in order to form a learning experience, 4) providing instructions on specific tasks that will be completed by students, 5) students develop plans for projects that include ideas to get, 6) gather facts, assign different roles and tasks to each other and 7) organize thoughts and ideas. The results show that through this PjBL students are able to work together and become better than before, critical thinking and creativity can show patience with each other (Tsybulky & Rozanoy, 2019).

This is in line with the results of interviews to IAIN students Sheikh Nurjati Cirebon that in the process of practicum activities that have been done less creatively in their implementation, students feel less excited in practicum implementation, especially during the COVID-19 pandemic which requires students to carry out pratikum activities at home so that students need help as practicum companion, one way that can be used in practicum to facilitate students. This is by using a STEM approach. Where this STEM approach will be conceptualized in accordance with the actual pratikum and will not make students feel confused in carrying out practicum at home. Students will be more creative in the implementation of pratikum in accordance with the material delivered, namely conventional biotechnology materials.This material is in accordance with the concept that will be conveyed to students will change in the process of critical and creative thinking, especially learning projects associated with conventional biotechnology so that students will produce products.

## METHOD

The research done is with quantitative research. This study was conducted for 2 months starting from May-June 2021. Data collection techniques are carried out in the form of observation sheets, tests and questionnaires. Observation sheet to measure student activity, tests are given to find out the critical thinking skills and creativity of students using pretest tests and posttets and questionnaires to measure student response. Practicum uses STEM approaches with the help of conventional PjBL practicum models and practicums, in accordance with the RPS that has been created. Carry out the practicum process in the MIPA Laboratory. In practicum control is done conventionally. When the implementation of practicum activities students are given LKP.In the implementation of practicum taken data retrieval includes: observation sheet, test and questionnaire.

After completion of the practicum using a STEM approach based on the PjBL model, the collection of practical response data is taken through the questionnaire. The study was conducted in two different classes: the experimental class and the control class (R1,2). Both classes in the study were given different treatments. O1 and O1 are the ability to think critically and creatively of students before there is treatment. O2 and O2 are the ability to think critically and creatively practicing after treatment. The process of testing problem instruments, observation sheets and questionnaires, aims to validate the feasibility of the instrument to be used in the research.

## RESULTS AND DISCUSSION

*Implementation of practicum stem approach based on PjBL model online*

Table 1. *Implementation of PjBL model-based STEM approach, by observer*

| Stages Learning | STEM Approach Stages of PjBL model | Implemen tation(%) |
|---|---|---|
| Early activities | Start woth essential question | 100 |
| | Desigh a Plan for the Project | 100 |
| | Create a Shedule | 100 |
| Core Activities | Monitor the Students and the Progres of the Project | 100 |
| Closing Activitie s | Assess the Outcome | 100 |
| | Evaluate the Experince | 100 |

Practicum using a STEM-based approach based on PjBL strongly supports the student practicum process when done at home or in the MIPA Laboratory IAIN Syekh Nurjati Cirebon because at the time of implementation builds student creativity in carrying out practicum activities.The implementation of the PjBL model-based STEM approach by researchers during three meetings is no obstacle, because during the practicum phase it is carried out very well. The implementation of the PjBL learning model by researchers and students in this study is as follows: start with essential to desigh project, create schedule, (monitoring the students and progress off project), assess the outcome, evaluation the experience.

STEM shortening PjBL learning is project-based learning by identifying STEM fields, because science requires mathematics as a tool in data, while technology and engineering are applications of science. Some of the benefits of STEM approaches make students able to solve problems for better, innovative, independent, logical thinking, and technological literacy (Hasanah & Luthiyatun, 2019). Science learning that is in accordance with the STEM approach is one of them is the PjBL model, because by integrating STEM fields that can provide opportunities for students to learn contextually through complex activities such as exploring, planning learning activities, carrying out projects collaboratively, and ultimately producing a product outcome (Mortis & Ennis, 1996).

*Improved critical thinking skills*

Table 2. *Critical thinking skills pre-test of each indicator*

| Class | Critical Thinking indicator | Score |
|---|---|---|
| Control | Interpretation | 12.00 |
| | Analysis | 38.40 |
| | Evaluation | 19.20 |
| Experiment | Interpretation | 20.00 |
| | Analysis | 36.00 |
| | Evaluation | 21.60 |

Table 2 shows the results of critical thinking skills research per pretest indicator that shows critical thinking information in the highest experimental group on the analysis indicator, while in the control class the highest critical thinking skills on the analysis indicator. Critical thinking skills are part of high-level thinking skills. Conventional Biotechnology practicum activities in making food products are activities that invite students to think critically, because in biotechnology practicum there are aspects of analysis, evaluation, interpretation and explanation that require students to manage it.

Table 3. *Critical thinking skills post-test of each indicator*

| Class | Critical Thinking indicator | Score |
|---|---|---|
| Control | Interpretation | 20.00 |
| | Analysis | 64.00 |
| | Evaluation | 39.20 |
| Experiment | Interpretation | 36.00 |
| | Analysis | 70.40 |
| | Evaluation | 45.60 |

Table 3 shows posttest results of critical thinking skills research per indicator that show critical thinking skills in the highest experimental group on the analysis indicator, while in the control class the highest critical thinking skills on the analysis indicator.

The presentation of the results of the average gain is normalized in the critical thinking skills of students in experimental and control classes in conventional biotechnology practicums.

Table 4. *Critical thinking gain index in experimental and control classes*

| Class | *pretest* | *posttest* | gg | Criteria |
|---|---|---|---|---|
| Experiment | 28,20 | 30,84 | 0,42 | Medium |
| Control | 28,32 | 26,16 | 0,18 | Low |

Based on the results of calculations obtained Fcalculated 1,083 < Ftabel and a significant value of 0,022 > 0,05 it can be concluded that both groups have the same variant.The calculation results obtained Fcalculate 4,24 < F Table and significant values 0,724 > 0,05 then it can be concluded that both groups have homogeneous data variance or have the same variant. According to the variance of the experimental and control classes is said to be homogeneous if sig values. Levene Statistics test >.0,05.

There was no difference in the average critical thinking ability of pretest data between the experimental class and the control class. This is evidenced by the calculated t value of 1,737 < t table 2,02 and a significant (p value) of 0,089 which is greater than 0,05. The results of statistical tests with the t test showed that there was no difference in the critical thinking skills of the experimental class with the critical thinking skills of the control class.While there is an average difference from the posttest data critical thinking ability between the experimental class and the control class. This is evidenced by the calculated t value of 0,649 > t table 2,02 and a significant (p value) of 0,522 which is smaller than 0,05. The results of the statistical test with the t test showed that there was a significant difference between the critical thinking ability of the experimental class and the control class at the time of the final test/ posttest.

Improvement in critical thinking skills can be known from the normalized N-gain gain gained from the initial test and the final test which uses 10 esay questions covering three aspects namely; interpretation, analysis, and evaluation. The difference in critical thinking skill levels between the experimental class and the control class that the average score of the final test result/posttest of the experimental class critical thinking ability is 71,80; standard deviation 14,20; high value of 90,00; The lowest value is 50,00. While the average score of the final test results / posttest of critical thinking skills of the control class was 69,80; standard deviation 10,29; The highest value is 80,00 and the lowest value is 30,00.So the results of this study can be concluded that there is a significant difference between the critical thinking skills of students who are given treatment with stem approaches using the PjBL model in the implementation of practicums with critical thinking> of students who use practicum conventionally. This is evidenced by a significant value of 0,015 smaller than 0,05.

The difference in students' critical thinking skills between experimental classes and control classes is due to in the experimental class in practicum implementation using a STEM approach based on the PjBL model by making products whose steps facilitate critical thinking skills activities, namely interpretation, this is because in the control class more opinions are conveyed by lecturers than students themselves who ask lecturers. The results of this study show that the achievement of critical thinking skills has more influence on interpretation indicators. Aspects of this interpretation such as working on projects to students then later the results of the prodak made presented in front of lecturers and classmates. Students' critical thinking skills can be done by producing a product with new findings in the learning process (Juhariyah et al., 2017)

Then the second is that students must prepare project planning where students must be able to analyze problems related to the preparation of project planning that will be practiced in accordance with the relevant material. Project planning that must be done by students must be in accordance with the procedures provided by lecturers, namely with a STEM approach so that the implementation is in accordance with the expected results and produce the perfect product. After preparing the project planning students must also draw a schedule in advance so that the implementation of practicum does not coincide with the schedule of biotechnology courses in the class. So that the practicum planning process can run smoothly.

Furthermore, students must be able to monitor the process of practicum activities taking place, so that students can participate actively when discussing groups and practicums themselves at home, so that the results of product planning made during practicums do not fail and understand what the benefits of the practicum process that is being done. From this problem that will arise critical thinking skills by students in practicum activities.Then the last is to evaluate the experience after doing preticum activities. Students can explain their own experience and are able to think critically whether practicum using PjBL-based STEM approach can be implemented properly or can be used for subsequent practicums, or is the practicum less effective because it requires a concept that is too long in the process of its

p-ISSN 2614-8250, e-ISSN 2614-5677
https://journal.uniku.ac.id/index.php/IJLI

activities, from this evaluation can provide input to practicum activities.

The existence of PjBL-based practicum activities can provide solutions to conduct practicums at home, because with the limitations of the tools used to make students more creative how to keep practicum even though the facilities and infrastructure are not fulfilled, teetapi with the practicum PjBL students are required to be creative with the tools and materials that exist only in the home and the environment around the residence. Critical thinking skills can help learning success, in critical thinking, in addition to involving processes also involving critical thinking skills such as predicting, Analysis, synthesizing, evaluating, reasoning (Susanti, 2019).

Analytical thinking is a decision-making process consisting of reasoning ability and the ability to determine decisions, select appropriate information for implementation, assume related hypotheses and conclude logically (Tiruneh et al., 2019). Because in the practicum implementation system carried out, students can carry out activities in accordance with the stages of STEM approach based on project based learning in the practicum worksheet so as to facilitate student creativity in the manufacture of products produced, namely by making food products in conventional biotechnology in traditional food ingredients from sweet potatoes and soybeans that will produce useful food products.

Practicum learning process in the Laboratory can provide experience for students both in the cognitive, affective and psychomotor realms. In the realm of cognitive practicum provides benefits in helping students understand the material taught in the classroom. In the realm of psychomorik practicum can train the skills of students in using tools and materials appropriately.

The use of STEM-based LKP is structured in a more practical and effective manner, because the arrangement in the LKP already has stages of planning that will be done by students, so that in doing it can be easier. Saintifically arranged LKP is able to improve students' initial ability in the learning process and can be used independently because it is equipped with instructions for the use of each activity (Lepiyanto, n.d)

*Enhanced student creativity through PjBL model-based STEM approach*

The data used in this study is data on product performance results from student creativity. An overview of the results of student creativity product performance in experimental classes and control classes is presented in table 5.

Table 5. *Description of creativity data of both classes*

| No | Creativity statistic | Experiment | Control |
|---|---|---|---|
| 1 | Average | 58,42 | 50,92 |
| 2 | Standar deviasi | 4,52 | 4,18 |
| 3 | Maximum value | 65,00 | 40,00 |
| 4 | Minimum value | 49,00 | 56,00 |

The table showed that the results of the creativity product results of students in the 6th semester tadris biology experimental class with an average score of 58,42; stadar deviation 4,52; high value of 65,00; The lowest value is 49,00. While the results of the creative performance of the control class with an average score of 50,92; standard deviation 4.18; high value of 56,00; The lowest value is 40,00.

The assessment of student creativity was carried out at the time of the creation of a project that included four indicators, namely smoothness, flexibility, originality, elaboration. Assessment of student creativity per indicator can be seen in the score contained in the total indicator value obtained from student creativity. The highest value on the flexibility indicator and the lowest value are in the elaboration indicator.This is because creativity will be clearly seen based on practicum carried out, namely on indicators of flexibility, because in indicators of flexibility can accelerate the process of practicum implementation that is ongoing, not only that practicum activities will also be completed quickly, because students will be more flexible in practicum wear so as to facilitate the results of prodak obtained during practicum activities.

Increased creativity is done through various efforts that support the emergence of creativity, in addition, the factor that encourages creativity is flexibility in doing what is being done, so that the results can be well done because it is done in accordance with flexibility and correctly (Sholikah, 2019).

Indicators of flexibility have the highest value because it is seen in the implementation of practicum many students who dare to ask questions or opinions, so that the atmosphere of practicum becomes more active, students also appropriately in providing answers can even give answers critically, this is because the explanations conveyed by lecturers can be captured both by students, so as to be able to come up with ideas when arguing.Learning delivered by conducting analytical activities, evaluating, and creating

product sutu will enable students to achieve high-level thinking skills (Fetriyana et al., 2020).

While in the elaboration indicator get a redah value because students have not been able to detail in detail about a problem and certain conditions well. This can be explained, because in the initial practicum students are not used to the implementation of group activities, such as in the implementation of practicums in MIPA Laboratories conducted in groups, so that at the time of discussion the student group is still not used to doing tasks together with his friends. Unlike when students are accustomed to doing tasks in groups, surely students will be better in the elaboration indicators in the practicum.Increased creativity is done through various efforts that support the emergence of creativity, in addition, the factor that encourages creativity is elaboration in doing what is being done, so that the results that are done will be lighter if done together and in group discussions (Barlenti et al., 2019).

Elaboration indicators in experimental classes are higher than control classes because experimental classes using PjBL-based STEM approaches train students to think about solving complex problems, investigating and understanding.Tasks and products that are classified as good are tasks and products that are different from ordinary or innovative because innovative products are products that result from students' creative thinking through learning using Project Based Learning (PjBL) which is a project-based process, thus producing good creative product value for students.

*Student response to practicum with STEM approach*

Student response to practicums using STEM approaches based on the PjBL model obtained data that student response scores, strongly disagreed by 0%, categories disagreed 1%, while categories agreed 67% and included categories strongly agreed as much as 32%. This shows that students have a good response to the STEM approach based on the PjBL model that has been implemented.

Most students agree that the STEM approach based on the PjBL model attracts students because the products made are related to daily life and in fun presentation activities are carried out because of the activities that assess each student's products by lecturers and practicum assistants delivered.

Students feel the PjBL-based STEM approach can make it easier to understand the concept of conventional biotechnology courses, because students only get theory, surely students do not necessarily understand the concepts studied, but if directly practiced by making products related to the theory of the courses students will better understand the concept of the material obtained and can develop critical thinking skills, interpret, Analyze, evaluate, differentiate and be confident. In addition, PjBL is also seen as able to improve students' skills in designing products with practicum results that have been done, this event is evidenced by the creativity of students directly carried out in the prektiicum process so that it can be seen the conventional biotechnology products produced by students after practicum activities are completed.

PjBL products are considered by students to be very useful to be used as good food and drinks for consumption by the body, so most students strongly agree if PjBL practicum measures that accommodate STEM aspects are applied to other materials. Thus the results of the questionnaire can illustrate that the STEM approach based on the PjBL model has an effect on the critical thinking skills and creativity of students.The student's response to the use of PjBL-based practicum modules is that students are very happy and give a very high response in following the practicum using a project-based practicum Likewise, (Puspitasari, n.d) Project Based Learning is a learning model that involves students actively in designing learning goals to produce real products or projects, the use of Project Based Learning can also make students independent in making products with their own work.

So that with the learning methods applied, the practicum activities carried out in research can be applied to the next practicum process because it can provide more active and creative benefits for students, because with online practicum students become more independent and not dependent on constant practicums. carried out in the laboratory and always guided by the lecturer.

## CONCLUSION

Based on the analysis, it can be concluded that the implementation of STEM approach based on the PjBL model through online practicum in improving critical thinking skills and creativity of students in biotechnology courses at THE MIPA Laboratory IAIN Syekh Nurjati in semester 6 students is carried out very well. There was a significant average difference of critical thinking skills between experimental classes and control classes after the implementation of PjBL model-based STEM approaches through online practicums with classes that did not use PjBL

model-based STEM approaches in conventional biotechnology practicums making food and beverage products.Creativity of students in the experimental class is the highest indicator on flexibility and original, while the lowest indicator is in the smooth indicator. While the creativity of students in the highest indicator control class is in the flexibility indicator and the lowest indicator is in the elaboration indicator. Student response to the application of PjBL model-based STEM approach through online practicum in improving students' critical thinking skills and creativity in conventional biotechnology practicums at IAIN's MIPA Laboratory Syekh Nurjati in 6th semester students falls into the good category.

## ACKNOWLEDGMENTS

This research is supported by the Ministry of Biological Education, Kuningan University.

## REFERENCES

Barlenti, I., M, Hasan, & Mahidin. (2019). Pengembangan LKS berbasis Project Based Learning untuk meningkatkan pemahaman konsep. *Jurnal Pendidikan Sains Indonesia, 5*(1), 81-86.

Fitriyana., Toto., & Erlin. (2020). Implementasi model PjBL-STEM untuk meningkatkan keterampilan berpikir tingkat tinggi. *Jurnal Pendidikan Biologi*, *8*(2), 1-6.

Hasanah., & Luthiyatun. (2019). Pengembangan modul bioteknologi berbasis STEAM (Science, Technology, Engineering, Arts, And Mathematics) dilengkapi animasi flash untuk pembelajaran Biologi di SMA/MA. 65-75.

Hilna. (2020). Analisis proses pembelajaran dalam jaringan (Daring) masa pandemi Covid-19. *Journal Elementary Education, 4*(4).

Juhariyah., Suwono., dan Ibrohim. (2017). Scince, Technology, engineering and mathematics project based learning. *Jurnal pendidikan sains IPA, 2*, 2-7.

Lepiyanto. (n.d). Implementasi Lesson study pada metode numbered heads together dipadu dengan team games tournament untuk pengembangan karakter siswa kelas x sma negeri 1 kepnjen. *Jurnal Bioedukasi, 3*(2).

Morris., & Ennis. (1996). *Critical thinking*. Prentice Hall Inc.

Nurhikmayati. (2019). Implementasi STEAM dalam pembelajaran matematik. *Jurnal Didaktikel mathematics. Universitas Majalengka. 2*(2), 22-25.

Puspitasari. (n.d). Panduan penulisan soal HOTS.pusat penilaian pendidikan. 41-42

Ratna. (2019). Pengaruh metode CTL dan kemampuan berpikir logis terhadap hasil belajar ipa siswa kelas. *Jurnal Pendidikan, 6*(2), 254-258.

Sholikah, M. (2019). Peningkatan literasi biologi dalam penggunaan pembelajaran menggunakan inkuiri terbimbing di SMAN 1 Susukan. *Jurnal Alam Indonesia. 7*(2), 1-9.

Susantini. (2019). Pengembangan Lembar Kerja Peserta Didik (LKPD) berbasis pendekatan saintifik dalam praktikum biokimia. *Jurnal Inovasi Pendidikan. Vol 9*(1), 61-80.

Tiruneh, D.T., De Cock, M., & Elen, J. (2019). Designing learning environments for critical thinking: Examining effective approaches. *International Journal of Science and Mathematics Education, 16*(6), 1065-1089.

1. Tsybulky., & Rozanoy. (2019). Model Project Based Learning (PJBL) terintegrasi STEM untuk meningkatkan penguasaan konsep dan aktivitas belajar siswa. *Jurnal Pendidikan dan Biologi, 11*(2), 93-98.