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Analysis of Creativity and Critical Thinking Skills Through Project-Based Learning of Smart Solar Panel System

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ABSTRAK

The challenges of today's world of work are very complex. Not only abilities based on grades on paper but other supporting abilities must also be possessed by graduates. In this era, graduates are expected to have other skills to support their academic abilities. These skills are known as 21st-century skills. This research aims to determine the level of creativity and critical thinking of students in the sixth semester of the Electrical Engineering Education Study Program. Analysis of these two skills is carried out through project-based learning, taking the project focus on smart solar panels. The selection of research focus is based on bibliometric analysis, where in the last 10 years, research related to project-based learning on renewable energy for creativity analysis and critical thinking still needs to be carried out. The research method used in this research is descriptive research with a qualitative and quantitative approach. The data collection process was carried out through direct observation in the field and also through assessment sheets by colleagues and lecturers. Based on the results of data processing, results were obtained which showed that project-based learning was suitable for analyzing critical thinking skills and also honing creativity.

INTRODUCTION

A new pneumonia case was discovered in Wuhan, China at the end of 2019. After doing some research, it turned out that this case was caused by the Coronavirus, which was finally called Covid-19 (Huang et al., 2020). The spread is so fast that the WHO has declared that COVID-19 is a pandemic. Social distancing is necessary to break the chain of the spread of this virus (Adedoyin & Soykan, 2023). Merriam-Webster dictionary referred to social distancing as a condition in which people must maintain a distance from one another say six feet or more. Avoid direct contact with people or objects in public places during a pandemic (Meriam, 2020).

The pandemic condition has a significant influence on several fields, such as education, economy, sports activities, and several other fields (Tathahira & Sriayu, 2020). They are forced to turn to online activities by utilizing information technology that is currently developing.

The spread of COVID-19 is evenly distributed in almost all parts of the world, including Indonesia. The government continues to enforce the policy of limiting community activities to prevent the transmission of the virus. Just like conditions in general, all fields of activity have also begun to switch to using the online system. One of the most prominent is teaching and learning activities. The learning process that initially runs face-to-face must adapt to online learning. This is not only limited to certain levels of education but at all levels of education, from early childhood education to tertiary education.

The learning process in universities during the pandemic is not much different from the general learning process. Lectures are conducted online by utilizing the available meeting facilities. One of the universities that were also affected by the pandemic was Universitas PGRI Madiun.

The Electrical Engineering Education Study Program also conducts online lectures. Initially, both theoretical and practical learning were conducted online, but this condition was

not very supportive, especially for practicum courses. It is very inefficient if practical learning is done online, considering that practicum does not only require academic ability but also practice. This is certainly very influential in the development of student skills. Moreover, nowadays the demands of the world of work are getting higher. College graduates are not only required to be academically capable but also to have adequate skills. The needs of the industrial world are getting higher day by day, and this incidentally must be met by current graduates.

The 21st-century has provided significant changes in all aspects of life, including education. Students studying in the 21st century must develop skills that are different from those developed by students in the last century (Saleh, 2019). Various challenges of the 21st century must be faced by the next generation of this nation. Facing the challenges of the 21st century, considerable contributions are made by the world of education. The world of education today does not only focus on knowledge but has been developed in terms of skills (Albar, 2021).

21st-century skills are very important for students to have to prepare themselves for the future world of work (Prastyaningrum et al., 2023; Bani-Hamad & Abdullah, 2019). To face the challenges of the 21st century, the promotion of various skills is currently being developed. This is of course done to the younger generation in this case are students who are ready and reliable to face the future. These skills are called 21st-century skills commonly referred to as 4C, namely collaboration, communication, creativity and critical thinking (Laar et al., 2020; Redhana, 2019; Yokhebed, 2019).

Several studies related to 21st-century skills have also been carried out. Among them is the application of creative learning cycles that can help hone 21st-century skills. Where this method is also supported by the use of LMS to hone creativity (Septiana, 2021). In addition, to determining critical thinking skills, it can also be done using STEM through project-based learning (L. Mutakinati et al., 2018).

However, based on bibliometric analysis, it appears that in the last 10 years research regarding the relationship between creativity and critical thinking with project-based learning, especially in the field of renewable energy, has not been carried out much. Based on Figure 1, it appears that there is no link between project-based learning and 21st century skills in the field of renewable energy.

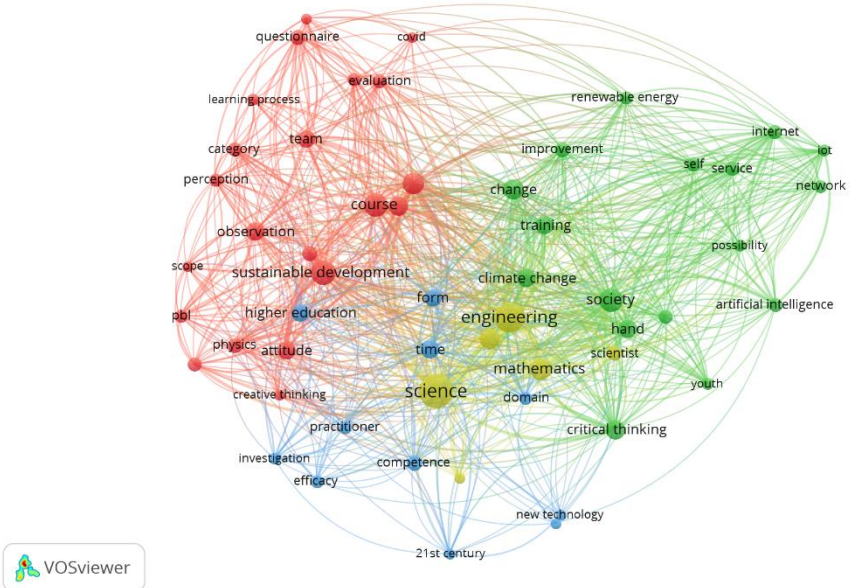

Figure 1. Network visualization for bibliometric analysis

Creativity and critical thinking skills are two types of 21st-century skills that are to be analyzed through the Smart Solar Panel independent project activities, or what we are more often familiar with project-based learning. As we all know project-based learning in the scope of higher education involves student activity. Learning that connects the theory of knowledge with everyday life, where students not only learn in theory but also practice directly (Barak, 2021; Wu & Wu, 2020; Barak & Usher, 2019; Prastyaningrum & Pratama, 2019).

The implementation of the project, which is entirely left to students, is intended to train creativity and critical thinking skills. For example, when determining ideas, students must look for ideas that are in sync with the current scarcity of fossil energy conditions, as well as what the students will do is needed by the industrial world. Besides that, students must also be able to realize these ideas into ready-to-use real products as well as convince the industrial world to be willing to accept the products they have made.

With this model of learning activities, students' creativity and critical thinking abilities can be analyzed. Such analysis is very necessary so that in the future it can be used to evaluate the implementation of learning, especially those related to 21st-century skills. Debriefing related to 21st-century skills is intended so that when students have graduated, they can have and master various skills. Armed with a variety of adequate skills, they can adapt to the demands of the world of work and the development of the current era.

The process of providing student skills is carried out through project-based independent learning. Project-based learning is a learning model that puts students at the center. Students can also learn knowledge and skills by learning more about a problem and how to investigate it (Dimmitt, 2017).

The project-based learning activities carried out are expected to be used as an alternative to foster students' creativity and critical thinking skills. This project-based self-learning design is one of the efforts to carry out practical learning while still complying with government regulations. The project-based independent learning process is carried out by providing independent projects to students. Where the entire process from the beginning to the end students have been involved in its implementation.

The process from determining the project, and finding partners, to making products all involve students. Smart Solar Panel was chosen as a form of a project to be worked on. In making smart Solar Panel several activities can be divided into making. This is used to hone students' critical thinking and creativity skills. Students are divided into several groups with the focus of air respective project areas. Each group works on one element of the independent project. For example, making controls, assembling solar panels, and other activities. Then from the independent project activities, assessments related to critical thinking and creativity were taken. These two are the two parts of the four 21st-century skills.

The selection of Solar Panel is based on current energy needs. The condition of depleting fossil energy has led to the need to develop alternative energy, one of which is solar power. Based on observations, one of the causes of the large costs required for the use of solar panels is maintenance costs, especially in the condition of the circuit bolts and batteries. Starting from this, we tried to design the Smart Solar Panel. On the smart Solar Panel, we use a control system to perform maintenance on the Solar Panel. The condition of the bolts that are getting looser and looser because of the effects of vibrations rethemed it can be known only through the smartphone application. So condition control, especially on the circuit bolts and batteries, can be done online.

METHOD

The research method we use is a descriptive method with a quantitative approach. Descriptive research is a problem-solving procedure that wants to be researched. In this method, the state of the subject/object of research is described based on the facts that appear as they are

(Nawawi, 2005),

The approach is quantitative. The quantitative approach is presented in the form of data in the form of numbers (Donatus, 2016). The quantitative approach is based on collecting and analyzing quantitative data, using survey and experimental strategies, conducting measurements and observations, and carrying out theory testing with statistical tests (Muhajirin et al., 2024).

The data collection process is carried out by giving an assessment questionnaire to students. Direct observation is carried out through observation and assistance to students from the beginning of determining ideas to the stage of promoting their products to the industrial world.

The things observed were based on the forms of creativity mentioned by the Ministry of Education and Culture. The first is the ability to convey new ideas both orally and in writing and develop and implement them. Second, students can be open and responsive to new and different perspectives. Third, the student can express creative ideas both conceptually and practically. Fourth, the knowledge that students have can be used in new and different situations, both in one subject, between subjects, and in contextual problems. Another thing that needs to be considered in analyzing students' creative abilities is their ability to use failure as a vehicle for learning, be able to create novelty based on their prior knowledge, and be able to adapt to new situations, and make a positive contribution to the development of the environment (Istiqomah, 2018).

Meanwhile, to analyze critical thinking skills, there are several indicators used. Indicators of critical thinking according to Fisher include the ability to identify problems, collect various relevant information, compile a number of alternative solutions to problems, make conclusions, express opinions, and evaluate arguments. We use the indicators of the two skills as a reference for making observations and preparing questionnaires for the data collection process (Fisher, 2008).

This research was conducted at the Integrated Laboratory and Electrical Engineering Education Laboratory of PGRI Madiun University. The study took a population of all students of the PTE study program with a sample of Semester VI students.

RESULT and DISCUSSION

Result

Data is obtained through the process of filling out questionnaires. Data processing using Microsoft Excel. Based on the results of data processing, the results are shown in Tables 1 and 2. The data analysis technique used in this study used a Likert Scale. The Likert scale is used to measure the level of creativity and critical thinking of students (Sugiyono, 2011). The data obtained from the questionnaire results were converted into values with four scales.

Table 1. Results of Student Creativity Questionnaire Assessments

No	Indicator	Result	Interpretation
1.	Convey ideas in writing and orally	3,7	Good
2.	Accept new, different opinions in an open and responsive manner	3,8	Good
3.	Analyze emerging ideas both conceptually and practically	4,0	Good
4.	Applying basic knowledge possessed in realizing existing ideas	3,6	Good
5.	Keep trying when it fails in the tool-making process	3,7	Good
6.	Apply some of the innovations from the knowledge they have gained	3,9	Good

No	Indicator	Result	Interpretation
7.	Show good adaptability to new situations and contribute positively to the environment.	3,7	Good

Table 2. Results of Student Critical Thinking Questionnaire Assessments

No	Indicator	Result	Interpretation
1.	Using inductive and deductive reasoning to identify problems	3,6	Good
2.	Analyze the relationship between some relevant information obtained	3,8	Good
3.	Analyzing several alternative solutions	4,0	Good
4.	Arrange the conclusions based on the data analysis results	3,8	Good
5.	Able to express opinions and evaluate arguments	3,8	Good

Discussion

Based on the results of observations made and supported by questionnaire data, findings related to students' creativity skills were obtained. Where students can come up with ideas as well as put forward ideas that arise. This can be seen from the way students make presentations regarding their ideas. The presentation is equipped with a complete visual picture of the idea, making it easier for the audience to understand the idea conveyed.

The second indicator is the openness of students in accepting some input and other views openly and responsively. Processing some of the opinions expressed later, to then be used as material for evaluating ideas.

Next is the ability of students to analyze existing ideas both conceptually and practically. This can be seen from the logical arguments put forward by students when defending their ideas, but do not limit themselves to the opinions or views of others on their ideas. Besides that, students are also able to show a practical picture accompanied by facts related to the realization of their ideas.

The fourth indicator is that students can apply their prior knowledge to realizing the idea. An example is the basic programming skills, where they apply the knowledge, they have gained to create a control system on the smart Solar Panel as well as overcome the problems that arise when making this control system.

The next indicator of creativity skills is an unyielding attitude. In the implementation of the Smart Solar Panel independent project, students showed an unyielding attitude. Where this attitude appears from the persistence of students to keep trying when their projects have not been successful. Some of the errors in their series were analyzed to then look for solutions to solve the problem.

The next creativity is giving a touch of innovation and adapting to new situations. Where later can make a positive contribution to the environment. This can be seen from the benefits provided by Smart Solar Panel, especially in the industrial world. Several touches of innovation were given by students to Smart Solar Panel, for instance, a maintenance system that has been equipped with a control system that makes it easier for partners to carry out periodic maintenance on Solar Panel poles.

Based on the description of the seven creativity indicators, it was found that the process of project-based learning activities, by taking the independent Smart Solar Panel project was able to optimize students' creativity skills. The learning process is completely student-centered from idea generation to execution and the last is to establish cooperation with partners, all carried out by

students. where students play a full role in honing their creativity so that their ideas can be realized. Students also have an active role in solving problems that arise when making Smart Solar Panel. The results obtained are in line with research conducted by Siti et al in 2019 which states that there is an increase in creativity through project-based learning (Ummah et al., 2019). To develop creativity, a conducive environment is needed, full support from educators, where teaching staff in this case lecturers provide full opportunities for students to explore their creativity. Provide students with the opportunity to play an active role in the learning process (Septikasari & Erasandy, 2018).

In addition to creativity skills, critical thinking skills must also be possessed by students. Critical thinking can be defined as a process of analyzing and synthesizing. In addition, it is also able to evaluate information collected or generated through reflection, reasoning, or communication, in order to produce valid, strong, and durable arguments and conclusions that can provide evidence. (Chusni et al., 2020). Project-based learning activities for Smart Solar Panel provide opportunities for students to practice critical thinking skills. Critical thinking skills are needed when the learning process is carried out independently (Wijaya et al., 2017).

The Smart Solar Panel project, apart from analyzing and training creativity skills, is also intended to analyze students' critical thinking skills. Critical thinking skills are very important for students. Someone who has critical thinking skills makes it possible to communicate well (Oktavia & Ridlo, 2020).

Based on the research results, students can identify problems well, this is evident from the emergence of ideas related to Smart Solar Panel. The second indicator is that students can understand the relationship between Smart Solar Panel and relevant sources of information. Students use this source of information as a theoretical basis for making a Smart Solar Panel. Students look for sources both from available articles and books. They connect one source to another so that it can be used optimally as a theoretical basis.

Furthermore, the indicator of student critical thinking is the ability of students to analyze problems and alternative solutions to these problems. This can be seen when students face problems in the process of making Smart Solar Panel, they work together to find solutions. Then try to apply some alternative solutions that have been obtained. Students are also able to conclude the problems found and the solutions applied, complete with the results of the analysis. Students can formulate conclusions in detail and are easy to understand, based on an analysis of the facts in the field. The last indicator is the ability of students to express their opinions regarding the overall project they are carrying out. Students can also evaluate some of the opinions expressed by other parties. Where the evaluation provided is complete with supporting theories and facts that occur in the field.

CONCLUSION

Based on the results of the analysis that has been done, it is concluded that project-based learning packaged in the form of independent projects can help optimize students' creativity and critical thinking skills. The results of the analysis of these two abilities can be more optimal because the learning process is student-centered. Students are given full rights to explore their abilities in completing the Smart Solar Panel project. The limitation of this study is that the data obtained through the questionnaire method allows for the occurrence of filling out questionnaires by respondents who are less serious in filling out the questionnaire which can lead to less than optimal results. Suggestions for future research can add the number of question items on each indicator.

REFERENCE

Adedoyin, O. B., & Soykan, E. (2023). Covid-19 Pandemic and Online Learning: The Challenges and Opportunities. *Interactive Learning Environments*, *31*(2), 863–875. https://doi.org/10.1080/10494820.2020.1813180

Albar, S. B. (2021). Problem and Project-Based Learning Through an Investigation Lesson: Significant Gains in Creative Thinking Behaviour Within the Australian Foundation (Preparatory) Classroom. *Thinking Skills and Creativity*, *41*(3). https://doi.org/10.1016/j.tsc.2021.100853

Bani-Hamad, A. M., & Abdullah, A. H. (2019). The Effect of Project-Based Learning to Improve the 21st Century Skills among Emirati Secondary Students. *International Journal of Academic Research in Business and Social Sciences*, *9*(12). https://doi.org/10.6007/IJARBSS/v9-i12/6749

Barak, M. (2021). A Cultural Perspective to Project-Based Learning and The Cultivation of Innovative Thinking. *Thinking Skills and Creativity*, *39*(Query date: 2024-05-04 05:21:29). https://doi.org/10.1016/j.tsc.2020.100766

Barak, M., & Usher, M. (2019). The Innovation Profile of Nanotechnology Team Projects of Face-to-Face and Online Learners. *Computers & Education*, *137*, 1–11. https://doi.org/10.1016/j.compedu.2019.03.012

Chusni, M. M., Saputro, S., Suranto, & Rahardjo, S. B. (2020). Review of Critical Thinking Skill in Indonesia: Preparation of The 21st Century Learner. *Journal of Critical Reviews*, *7*(9). https://doi.org/10.31838/jcr.07.09.223

Dimmitt, N. (2017). The Power Of Project-Based learning Experiential Education To Develop Critical Thinking Skills For University Students. *CBU International Conference Proceedings*, *5*, 575–579. https://doi.org/10.12955/cbup.v5.988

Fisher, A. (2008). *Berpikir Kritis*. Erlangga.

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., … Cao, B. (2020). Clinical Features of Patients Infected With 2019 Novel Coronavirus in Wuhan, China. *The Lancet*, *395*(10223), 497–506. https://doi.org/10.1016/S0140-6736(20)30183-5

Istiqomah. (2018). *Pembelajaran dan Penilaian High Order Thinking Skills Teori dan Inspirasi Pembelajaran Era Revolusi Industri 4.0*. Pustaka Media Guru.

L. Mutakinati, I. Anwari, & Kumano, Y. (2018). Analysis of Student Critical Thinking Skill of Middle School Through STEM Education Project-Based Learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1). https://doi.org/10.15294/jpii.v7i1.10495

Laar, E. van, Deursen, A. J. A. M. van, Dick, J. A. G. M. van, & Haan, J. de. (2020). Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open*, *10*(1). https://doi.org/DOI: 10.1177/2158244019900176

Meriam, W. (2020). Definition of a Pandemic. In *Merriam-Webster Online Dictionary*. https://www.merriam-webster.com/ dictionary/pandemic

Nawawi, H. (2005). *Penelitian Terapan*. Gajah Mada University Press.

Oktavia, Z., & Ridlo, S. (2020). Critical Thinking Skills Reviewed from Communication Skills of the Primary School Students in STEM-Based Project-Based Learning Model. *Journal of Primary Education*, *9*(3), 311–320. https://doi.org/10.15294/jpe.v9i3.27573

Prastyaningrum, I., Imansari, N., & Kholifah, U. (2023). Analysis of Critical Thinking Skills and Collaboration of Electronic Engineering Education Students in Electrical Machinery Course. *IJIET (International Journal of Indonesian Education and Teaching)*, *7*(1), 114–120. https://doi.org/10.24071/ijiet.v7i1.5091

Prastyaningrum, I., & Pratama, H. (2019). The Application of Project Based Learning Method in Learning Micro-Hydro Electrical Power. *Journal of Physics: Conference Series*, *1171*, 012031. https://doi.org/10.1088/1742-6596/1171/1/012031

Redhana, I. W. (2019). Mengembangkan Keterampilan Abad Ke-21 dalam Pembelajaran Kimia. *Jurnal Inovasi Pendidikan Kimia*, *13*(1). https://doi.org/10.15294/jipk.v13i1.17824

Saleh, S. E. (2019). Critical Thinking as A 21st Century Skill: Conception, Implementation and Challenges in the EFL Classroom. *European Journal of Foreign Language Teaching*, *4*(1). http://dx.doi.org/10.46827/ejfl.v0i0.2209

Septiana, A. I. (2021). Twenty First Century Skill Attainment Using Creative Learning Cycle Method with Learning Management System Media (A Case Study of Basic Programming Subject in 11th Grade Computer and Networking Study SMKN 1 Cimahi). *Journal of Software Engineering, Information and Technology*, *2*(1). https://doi.org/10.17509/seict.v1i1.29891

Septikasari, R., & Erasandy, R. N. (2018). Keterampilan 4C Abad 21 dalam Pembelajaran Pendidikan Dasar. *Jurnal Tarbiyah Al Awlad*, *8*(2).

Sugiyono. (2011). *Metode Penelitian Pendidikan*. Alfabeta.

Tathahira, & Sriayu. (2020). The Implementation of Online Learning During Covid-19 Pandemic: English Teachers' Perceptions at Senior High Schools in South Aceh. *Indonesian Journal of Curriculum and Educational Technology Studies*, *8*(2). https://doi.org/10.15294/ijcets.v8i2.40237

Ummah, S. K., In'am, A., & Azmi, R. D. (2019). Creating Manipulatives: Improving Students' Creativity Through Project-Based Learning. *Journal on Mathematics Education*, *10*(1), 93–102. https://doi.org/10.22342/jme.10.1.5093.93-102

Wijaya, U. R. B., Sumarni, W., & Haryani, S. (2017). Pengembangan Instrumen Penilaian Berpikir Kritis Pada Pembelajaran Kimia Berpendekatan Sets (Science, Environment, Technology, and Society). *Journal of Chemistry in Education*, *6*(2).

Wu, T.-T., & Wu, Y.-T. (2020). Applying Project-Based Learning and SCAMPER Teaching Strategies in Engineering Education to Explore the Influence of Creativity on Cognition, Personal Motivation, and Personality Traits. *Thinking Skills and Creativity*, *35*, 100631. https://doi.org/10.1016/j.tsc.2020.100631

Yokhebed. (2019). Profil Kompetensi Abad 21: Komunikasi, Kreativitas, Kolaborasi, Berpikir Kritis Pada Calon Guru Biologi Profile of 21st Century Competency: Communication, Creativity, Collaboration, Critical Thinking at Prospective Biology Teachers. *Bio-Pedagigi (Jurnal Pembelajaran Biologi)*, *8*(2). https://doi.org/10.20961/bio-pedagogi.v8i2.36154