STEM based Project Learning: How It Affects Preservice Science Teacher's Creativity Before, During, and After Pandemic Covid-19?

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Article Info	Abstract
	Creativity Are the important skills to face the globalization in this era. Students, especially preservice teacher should have these useful skills for make next generation are more creative, struggling with the competition between human and computers, struggling with the world condition during and after pandemic strikes, and well prepared for their work field. Some of the learning approaches have been applied in the courses to construct their creativity, one of them, are STEM (Science, Technology, Engineering, and Mathematics) by the project. This research's aim is to investigate how is preservice science teacher's creativity by the STEM based project learning before, during, and after pandemic covid-19. The method that is used is qualitative research by using class observation and quantitively count by creativity rubrics that includes creative thinking, behaviour, and products. This instrument is adopted from PBLWorks creativity and innovation rubrics that has been validated by 3 experts. This research is conducted in SETS learning (2nd semester in every year) by using STEM based project from the students of science preservice teacher year 2019, 2020, 2021, 2022. STEM based project learning could improve preservice science teacher's creativity but it has differences for each class. From class 2019, 2020, 2021, and 2022 has decrease of improvement of creativity. Class 2019 has outperformed for creativity among others. While, class 2022 has less performed for creativity among others. Based on the observation, the covid-19 outbreak has high influence to this result because of the way of their learning in their high school before. Full online learning makes the biggest impact to science preservice teacher's creativity during covid-19 outbreak. **Keywords:** STEM based Project Learning, Creativity, Science Learning, Pandemic Covid-19

1. Introduction

Creativity is becoming important in this modern era (Beghetto & Kaufman, 2014; Richardson & Mishra, 2018; Yeh, *et.al*., 2012). Students specifically are an agent of social development on a

mission to nurture creative personalities and build creativity. Creativity also as one of the 21st century skills must have by the preservice science teacher as a person who will change the next generation in the future (Bjorner, *et.al*., 2012; Venckutė, *et.al*., 2020). Creativity is needed in this modern era for the purposes, one of them is to solve the environmental problem. As known the SDGs launch 17 goals that all the people in this world notice and aware that our environment is not in a good condition. Beside pandemic covid-19 strike this world, and make the crisis in the whole aspect, the worst crisis that will be faced by the next generations are the environmental problem. So, this world needs the creative generation to solve the environmental problem.

Education plays significant role to lead people creativity. Students as a human being that will implement their creativity in their society, should be trained continuously. Construct students' creativity in educations has several factors such as teacher or lecturer that should be trained professionally (Davies, *et.al*., 2014; Hosseini & Watt, 2010; Conradty & Bogner, 2020), learning media and topics that should lead students' creativity and generate their creativity (Tang, *et.al*., 2022), and also learning model, method, or approach that suitable to build students creativity (Sari, *et.al*., 2018), such as project-based learning (Elfeky, *et.al*., 2022; Isabekov & Sadyrova, 2018), problem based learning (Nurkhin & Pramusinto, 2020; Rudibyani, 2019), inquiry (Kadir & Satriawati, 2017; Zubaidah, *et.al*., 2017), and the most related one is STEM approach (Science Technology Engineering and Mathematics) (Kanematsu, *et.al*., 2016; Root-Bernstein, 2015; Üret, & Ceylan, 2021). Accordingly, several research are trying to identify how to develop students' creativity, such as lecturers' behaviors, encouragement and motivations (Chan, & Yuen, 2014). More recently, several research have started to investigate the role of the classroom environment (Tsai, *et.al*., 2015). All that research results could be a reference to foster students' creativity before pandemic covid-19.

Meanwhile, during pandemic covid-19 strike the world, learning environment or the way of learning should be an emphasis point. When pandemic covid-19 comes to the world, the educations sector has difficulties to arrange the learning. All the stakeholders, teachers, and students from elementary until higher educations used to be taken an online learning without face-to-face communications and technology skills should be trained and mount. This condition forces the education sector, especially science learning, to think about the best way to deliver material and train 21st century skills, one of them is creativity in online or distance learning. One of the appropriate learning steps is to use project-based learning and STEM (Elfeky, *et.al*., 2022; Kanematsu, *et.al*., 2016; Root-Bernstein, 2015) by selecting problems around the student's environment. STEM learning could cover either online or offline learning. In online learning, STEM could be applied by give the problem near the students, design and create the project as a solution by using applications, such as Canva, adobe illustrator, or another platform, and discuss and present using zoom or other platform (Sandrone, *et.al*., 2021; Van Nuland, *et.al*., 2020; Kleinke & Lin, 2020).

In fact, online learning has several advantages, such as not being limited by time and space, being able to seek knowledge and training across regions and countries, forming qualified ICT skills, and being able to use the internet to learn. The disadvantages of online learning are that students are less focused and distracted by activities other than ongoing learning, students are tired of communicating remotely using zoom, students lack discipline in doing assignments, students just want a quick way to do their assignments and projects by using AI tools, youtube without adapting it, but directly using it (Mirkholikovna, 2020; Kotrikadze & Zharkova, 2021; Sadeghi, 2019).

Notably, there is a lack of in-depth research on creative learning environments in relation to pandemic conditions in the literature, although experts suggest that student creativity can be nurtured by educators who put more effort in designing learning environments that emphasize the value of creativity (Davies, *et.al*., 2013; Richardson & Mishra, 2018). Therefore, in this study, using STEM-based project learning as one of the solutions to form a creative learning environment and increase student creativity with in-depth discussions that pay attention to learning conditions and situations such as the covid-19 pandemic.

This research is the first study to undertake longitudinal analysis of how to face the students' characteristic before during and after pandemic to determine the best learning approach, one of which is STEM project-based-learning so that their abilities are optimally trained, especially creativity. Despite using the same approach, there will be differences in each student's characteristics. Therefore, the urgency of this research is for educators to better understand the characteristics of students so that they can adjust to the best learning approach, one of which is using STEM-based project learning. As well as emphasizing more on certain parts of the STEM to be able to optimize learning in each student generation characteristic, i.e. before, during, and after the pandemic.

2. Methods

This study used qualitative research. Qualitative research conducted through in-depth learning observation. Qualitative research was conducted to see student (preservice teacher) activities, which are active in learning by using STEM. Observations were made on SETS (Science, Technology, Environment, and Society) learning courses which conducted in every second semester based on science education curricula. This study implemented for four years, starting from year 2019 until 2022. The first one in year 2019 with 5 students, second in year 2020 with 5 students, third in year 2021 with 8 students, and the last is in year 2022 with 11 students.

Students are asked to create a project based on the problems faced in accordance with the theme. Students are asked to identify problems that exist in their surrounding environment in accordance with the theme, then they analyze literature related to the problem and the solution ideas they make. Students design the idea into a design. After that, they make a prototype based on the design that

has been made. The final stage is that they present their prototype ideas to their peers and lecturers. This research takes data related to how student creativity in SETS (Science Environment Technology and Society) learning using the STEM-based project learning approach.

The instrument that is used for observation is adapted from PBLWork creativity and innovation rubric which has seven indicators. There are: 1) Launching the Project Define the Creative Challenge; 2) Building Knowledge, Understanding, and Skills. Identify Sources of Information; 3) Developing and Revising Ideas and Products. Generate and Select Ideas; 4) Presenting Products and Answers to Driving Question Present Work to Users/ Target Audience; 5) Originality; 6) Value; and 7) Style. Those indicators are scored as data analysis technique by simple percentages for each student and groups during observation, then make the average of those percentages. The criteria are: 1) 0% - 25% (Beginning); 2) 26% - 50% (Emerging); 3) 51% - 75% (Developing); 4) 76% - 100% (Demonstrating). Based on observation, there are additional data collection technique that is used was semi-structured interview. This technique is used for several data which has deviant or interesting data. The results also could be used to strengthen the main results and observation.

3. Result and Discussion

This research results describe about preservice teacher creativity after four year taking data which has reached in a good way for each education year. From figure 1, it can be shown that there is an experienced a decline for the preservice teacher creativity by the year. The results figure the preservice teacher who enroll in year 2019 (92%), 2020 (87%), 2021 (82%) which has reached demonstrating criteria in creativity and innovation. While, preservice teacher who enroll in year 2022 (67%) has reached developing criteria in creativity and innovation. All those results are reflected in the learning systems and patterns that vary each year. In addition, pandemic conditions have forced educational patterns to undergo adjustments, one of which was originally offline learning, adapting to online learning. Although we use the same approach, i.e. STEM (Science, Technology, Engineering, and Mathematics) based project learning, the different results from each year have been clearly described.

Learning conditions in university for online learning, begin in year 2019. The preservice science teacher in year 2019 are begin to learn with online learning from second semester that this research is conducted. Nevertheless, the student's creativity has the highest score and got demonstrating criteria, which means the previous learning has the biggest impact to their creativity. The previous learning means that those students who enroll in year 2019, has been done offline learning for their entire senior high school. They do face to face group discussions, direct presentations, direct investigation and identifications. While the students who enroll in year 2020, they began the online learning in their last year of senior high schools.

Then, for the students who enroll in year 2021, they began the online learning in their second year of senior high schools. While for students who enroll in year 2022, they have been done the online learning from the first year of their senior high school. It was the big impact to the students' creativity, means that students need hands on activity together with the groups. Different with the research Rogers-Chapman & Darling-Hammond (2013); García-García, *et.al.* (2017) that show online learning could enhance creativity, demonstrates that online learning provides an open environment for students, enabling them to exchange knowledge with others and enhance their creativity. The research (Zulfikar, 2020) also confirms that collaborative digital platforms have a significant impact on students' creativity, initiative, and critical thinking. Offline learning gives the positive impact to the students' creativity, while the online learning gives the positive impact to the students' technology literacy (Van Nuland, *et.al.*, 2020; Kleinke & Lin, 2020). If those learning are combined, it will have an excellent learning to cultivate students' 21st century skills through the powerful approach, one of them is STEM based project learning.
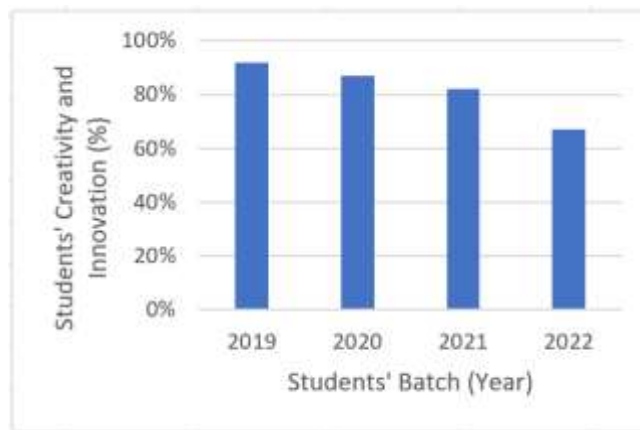

Figure 1. *Preservice Science Teachers' Creativity and Innovation through STEM based Project Learning*

Whereas, if full online learning is implemented for long term period, it would made students' skills decrease, especially creativity. It is in a line with the observations during learning, that students who learned by using zoom meeting, they feel a lot of fatigue, sometimes they do not get what lecturer deliver the topics, they always close the camera and microphone, they hesitate to ask the questions, and the most important is, they do not feel the engagement in learning and their friends even they discuss through zoom meeting. The students also lack of discipline to do the task, in this research, students ask to read literature review to identify the problem and find a solution. They just find the easy way, for example directly search on the google, YouTube, and ChatGPT to get the whole idea. Actually, those application and platform are really helpful and students could find the inspiration from that for their learning, not take the whole others idea. That habit should be gotten rid of the students' mindset.

Creativity that is discussed in this research, is about the creative process and product which is made by the students as a solution from the environmental problem as sustainability product innovations surround them. The results from each aspect of creativity are shown in the table 1.

Table 1. *Aspect of Preservice Science Teachers Students' Creativity and Innovations*

Aspect of Creativity and Innovations	Percentages of Students' Creativity and Innovations (%)			
	2019	2020	2021	2022
	Before Pandemic	During Pandemic		After Pandemic
Launching the Project Define the Creative Challenge	83	81	72	58
Building Knowledge, Understanding, and Skills. Identify Sources of Information	92	88	75	73
Developing and Revising Ideas and Products. Generate and Select Ideas	100	88	88	80
Presenting Products and Answers to Driving Question Present Work to Users/ Target Audience	100	94	91	80
Originality	92	81	84	40
Value	92	75	75	65
Style	83	100	88	75

Creativity aspect which has higher score are developing and revising ideas, product, then Presenting products and answer to driving question present work to target audience. Based on the data above that all students in each year got the highest percentages. Those because in revising the ideas, the students have already got the advices and other ideas from their peers and lecturer pertaining their project, then they perform better than initial idea. Students are also willing to accept other people's opinions openly, speak with good speech and respect other people's opinions. While in presenting the product aspect, all the students in each year also got the highest score, because they are trained to speak in front of large audiences even in pandemic conditions by using the zoom platform with online learning.

Beside the highest score that students have been reached in creativity and innovations aspect, the students also got the lower score in originality, especially for students in year 2022. They got the lowest score in originality aspect among other peers in each year. It because they develop the project not based on the problem surround them, but based on the problem that given by the lecturer, then they directly access the YouTube to make the project. They just copy and paste all the things about the project based on YouTube. They lack to read the article that has been given by the lecturer. For example, they create the project about how to reuse the waste things that become a problem in your environment near you. They choose the straw which can be transformed become pencil holder. They made them as a whole part following the procedures and shapes from YouTube.

While, students in year 2019, got the highest score in originality aspect among the other students. It is because they discipline to read the article that has been given by the lecturer, then they receive the problem from lecturer with the challenges that should be solved the environmental problem surround them. They start to investigate the environmental problem pertaining waste things near their living place. Then, they design the solutions discuss with the lecturer. So that, they found the highest originality and value for their product as a solution. They reuse the nutmeg bark which is abundant into a cracker which can be eaten by the people, and sell them to advance the economy of local residents.

As for the class of 2020 and 2021 who have the originality criteria is demonstrating, but slightly decreased in the number of percentages from the class of 2019. The class of 2020 still has a fairly high originality in creativity and innovation. When creating projects, they combine YouTube search techniques and reading articles side by side. They made one project called kamishibai in environmental learning. They combine environmental learning materials for junior high school students with Japanese storytelling techniques, kamishibai. They adapt by observing, imitating and modifying while creating this project. This made their style criteria score is perfect. The class of 2021, their originality seems remain the same with class of 2020. They priorities using technology to find solutions to problems in the surrounding environment. For example, they made promotions through social media regarding digital tickets and regulations at the Gunung Pangrango National Park (TNGGP) which was empty of visitors during the Covid-19 outbreak. The originality of their idea still gets a very good score, namely demonstrating. However, they made this innovation not purely from reading scientific articles, but videos from YouTube. From these results, it can be seen that the more students do online activities, the more interested students are in finding things from social media, videos, and other instant digital things.

Even the same approach that we used in the learning by using STEM based project learning, the same topic about waste things in environment, the same steps to do the learning by the project, the results show the different and tends to decline by the year. Apparently, the way learning begun, motivations, also influence the results. The way learning means that online and offline learning are very influential (García-García, *et.al*., 2017; Afari, *et.al*.,2013). Offline learning makes students feels engaged with their friends and lecturer. The more they engaged with the peers and lecturer, the more they feel easy to do the task and understood for the topics. While online learning, they do not feel the engagement, they feel lot of fatigue in front of the laptop, and they have limited space to move around for discussions with they friends. In a line with the research Lee (2018) that said used social technology and social capital theory to examine for the first time how knowledge sharing affects individual creativity among college students in online learning, as well as the mediating effect of knowledge sharing on individual creativity. Moreover, when they do the online learning, they could do another task such as another meeting, cooking, playing, watching tv, even more sleeping. So, they do not focus on the learning that is taking place. If this habit continues, it will affect pre-service science teachers' student skills that should be explored, will not appear. Such

as creativity, critical thinking, problem solving. So that, it can lead to loss generations. This is dangerous, because pre-service science teachers' students must be trained in these skills to be able to practice them on their students as the next generation and change the mindset of their students that science is fun.

4. Conclusion

This research could be concluded that online learning is very impactful to the pre-service science teachers' creativity. The students in year 2022 have been done full online learning from they began their senior high school. Different with students in year 2019 who has been done online learning in the second semester of university. Online learning makes them not engaged to their friend and lecturer, topics, and lack of understanding about the material. Online learning has much more distraction in their activity, so they difficult to focus on learning. Vice versa from offline learning that make them focus, engage each other and they more understand about the topics. So, pandemic era brings us to accelerate technology, but lack of engagement in educational sector.

5. Aknowledgments

6. References

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