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Strategy of Project Based Learning (PJBL) Based on Science, Technology, Engineering and Mathematics (STEM) in Growing Active and Creative Students

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ABSTRACT

The pandemic forced student learning to change, study at home, many new problems were encountered, one of which was a decrease in student activity and creativity. On the other hand, education in the 21st century must be able to facilitate students who are active and creative, adapting to changes in all situations. The aim of this study is to describe the integration of Project Based Learning based on science, technology, eigeneering and mathematics and its success in increasing creative active students. The method used qualitative case study comes from secondary and primary data, observation, documentation, interviews, and triangulation. The results of the study show that the integration of learning goes through the following stages: Pre-Learning Stage, teachers of several subjects collaboratively prepare various tools relevant to the theme; In the implementation phase, students are given the responsibility of completing a project in several weeks. The first week classifies project assignments, divides into groups, provides material, understands worksheets, listens to video links. Worksheet filling, and procurement of materials. The second week is product creation, the third week is completing work sheets, editing videos, making power points, and sending the results to the link. The fourth week is product improvement, the fifth week is the trial, and the sixth week is the work title; In the post-learning stage, evaluation is carried out, and follow-up, reports, dissemination of subject collaboration teams. Its success has increased students' enthusiastic learning attitudes, student creativity, learning enjoyment, competency improvement, and student project products.

Keywords: *Creative Active Student, Project Based Learning, Technology Eigeneering Mathematics*

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INTRODUCTION

Education is a continuous process to improve human life. Through education, humans are provided with information, training, development and learning so that they have life skills, are able to manage themselves and adapt to both internal and external changes.The purpose of education is to improve the quality of human life (Soltes et al., 2018). Because of the importance of education, it is important to maintain and maintain the existence of the educational process itself, because the dynamics and changes that continue to develop demand changes in the educational process. In the era of globalization, humans are required to adapt quickly and improve their quality of

life. The function of education is to keep humans safe in this life and also in the hereafter, in accordance with Surah Attahrim verse 6 in the Qur'an which emphasizes the need for humans to protect themselves and their families from the fires of hell (Syahbudin et al., 2022). Therefore, the leaders in this country created a strong legal umbrella to ensure that all citizens have the right to education (Ramos-Morcillo et al., 2020). Under normal circumstances, education is organized through formal, informal and non-formal institutions, so that all citizens have the same right to receive education, but the curriculum and its management must be adapted to the situation, climate and conditions of Indonesia which are regulated by law (Widodo et al., 2020).

Conditions in which learning is carried out face-to-face are not always absolute and can be carried out forever. Change will always occur in the human life system, for example in a force majeure situation such as an extraordinary natural disaster that can cause unrest, disaster, and uncertainty in human destiny. Therefore, education managers must be prepared to construct changes to the system that has been implemented to deal with these unexpected situations.

At the close of 2019, the COVID-19 outbreak originated, initially in Wuhan, China. COVID-19 rapidly spread to over 216 countries globally, including Indonesia. This particular virus, which has led to the decline or fatality of numerous individuals for over two years, belongs to the coronavirus family (Utku, 2023). This global pandemic resulted in extensive economic setbacks. As of now, as per the official WHO report, there have been 768,237,788 confirmed cases and 6,951,677 deaths reported worldwide in this epidemic (Sun & Sathasivam, 2023). During the initial phase of the COVID-19 pandemic, the World Health Organization (WHO) disclosed a crude case-fatality ratio (CFR) of 3.8% based on the first 55,924 laboratory-confirmed cases (Haider et al., 2023). In Indonesia, the inaugural case of COVID-19 was officially acknowledged by President Joko Widodo on 2 March 2020, in Jakarta. As of February 3, 2021, Indonesia experienced a significant impact from the COVID-19 pandemic, recording over 1,099,687 positive cases and 30,581 deaths (Prasetyo et al., 2021). As of 20 April 2022, Indonesia reported 6.04 million confirmed COVID-19 cases and 156,000 deaths. The country stands as one of the ASEAN nations most severely impacted by the COVID-19 pandemic, with a mortality rate of nearly 15.6 per 100,000 people as of 28 March 2021 (Charina et al., 2022). The emergence of the COVID-19 pandemic has brought about various transformations in numerous aspects of human life (Stecuła & Wolniak, 2022).

After the Covid-19 emergency period, schools were adapted to new habits and were allowed to open, although within limitations. In 2022, the government released new regulations regarding the curriculum in Indonesia through Kepmenristekdikti No. 54 of 2022 concerning guidelines for curriculum implementation in the context of learning recovery. This rule is also strengthened by Kepmendikbudristekdikti No. 262 of 2022 which confirms that there are 3 curricula implemented in Indonesia, namely K13 with complete core competencies and basic competencies, simplified 2013 Curriculum, and independent curriculum as a whole. The flexibility in using this curriculum provides an alternative and encourages schools to be more creative, as well as facilitates the management of diverse students both online and face to face. One of the schools that has responded well to the flexibility of the national curriculum is the 1 Kalijati State Senior High School, Subang Regency, which since 2020/2021 has implemented pure online learning or PJJ using a Learning Management System (LMS) design. This system allows schools to manage distance learning and facilitate student and teacher interaction through a special system that is always controlled, recorded

and controlled (Alismail, 2023). Student activity and creativity can be monitored and stored properly.

The strengths in the management system of Kalijati 1 Public Senior High School are expected to be able to maximize student learning outcomes in both cognitive, affective and psychomotor aspects. One aspect that is the focus is the aspect of active and creative student motivation in learning (Liu et al., 2023). These two aspects are expected to trigger the hopes of schools and all parties so that students are always ready to face global competition, even though they have to be faced with the limitations of learning activities during a pandemic.

Model Project Based Learning is a learning approach that actively involves students, both individually and in groups, in achieving learning goals by creating tangible products or works. By using Project Based Learning, the focus of learning shifts from simply memorizing concepts and relying solely on the teacher as the source of information. Instead, students are encouraged to actively participate, as they are required to complete various tasks such as group work, interacting with peers, and expressing their opinions during the learning process (Dinda & Sukma, 2021)

In this section BJBL is delivered in a STEM pattern. The term STEM was first used by the NSF (National Science Foundation) in 1990, an abbreviation for Science, Technology, Engineering and Mathematics. an interdisciplinary approach between Science, Technology, Engineering and Mathematics. The two terms are combined, PjBL refers to efforts to provide challenging assignments in the form of projects, and STEM refers to scientific procedures that are measurable, planned, evaluated using technological innovations that exist in the student's environment. STEM-based PjBL integration places more emphasis on the design process, a systematic approach to developing solutions to problems with well-defined outcomes. The PjBL STEM learning process guides students with five effective steps. The Reflection stage, motivates them to immediately carry out investigations, the Research stage, namely a form of student research. The Discovery stage, involves the process of connecting research with information during project preparation, the Application stage to test the product while solving problems, and the results obtained to improve the previous steps. And finally, the Communication Stage creates products/solutions through communication between friends and in class.

The PJBL-STEM learning process above leads students to be active and creative, but the project given is not comprehensively able to touch all existing subjects and materials, an effective and efficient step is needed so that its implementation can be integrated into a collaborative project between subjects. Another thing is that effective and efficient steps in implementing subjects after the Covid-19 pandemic have not yet led to efforts to activate and make students creative, there are only enough students who are served in their learning, this is certainly quite dangerous because the function of education has not been maximized, namely building students with active and creative character. even though learning conditions vary online or offline. Therefore, a comprehensive design strategy is needed to make project activities develop active and creative students.

Another thing is that the collaboration project between lessons has the principle that all existing phenomena will be related to each other. Talking about Health certainly cannot be separated from Education, or attitudes and behavior, therefore STEM-based PJBL is an alternative. Integration between subjects solves problems resulting in an active and creative attitude.

The design of integration between subjects in a project produces a certain character, something that has not been widely discussed by experts, because previous research only revolved around a partial deepening of each activity, both related to PjBL and STEM, separately. There is some discussion regarding the integration of the two, but it is still focused on one lesson and not yet on the collaboration process between subjects. Research results of Nur Afifah and Nur Ilmiyati. Regarding the Influence of the Project Based Learning (PjBL) Model with a STEM Approach on Students' Mastery of Concepts and Critical Thinking Skills, Afni concluded that there was a positive influence of learning activities using the STEM Approach Project Based Learning Project on students' critical thinking, in this case it did not discuss the integration of PJBL- STEM between subjects.

Therefore, the researcher provides an idea that leads to a project learning design strategy that seeks to integrate between subjects and produce several characters, namely active and creative characters. This is an urgent step to research so that there is an alternative strategy to develop student character in the post-Covid 19 pandemic era, so that our generation is more resilient and responsible for their duties and obligations as the younger generation.

Based on the initial survey at the time of the research, Kalijati State High School 1 Kalijati, Subang Regency used a variety of learning activities other than e-Learning, namely by conducting collaborative learning and implementing Project Based Learning (BJBL) learning designs based on Science, Technology, Engineering and Mathematics (STEM).) during the Covid 19 emergency. BJBL is a project-based learning process that integrates science and technology disciplines, aiming to make students more active, creative and able to use applications and devices in their environment in solving various life problems they encounter. As a result, many creative products from students emerged and almost all students in the group were able to show their creativity every time a work was held. However, to achieve this success, a long journey must be passed and limitations such as facilities, time, and opportunities for students and teachers are limited. Although this strategy has had positive results and data from school principals has shown an increase in student activity and creativity, this success requires deeper research.

METHOD

This research applies a qualitative method with the type of case study, which is a series of scientific activities carried out in detail and depth on various programs, events or activities of certain individuals, groups of people or institutions, with the aim of obtaining in-depth data and information (Baskarada, 2014). Arikunto states that case studies are a form of descriptive approach, in which research is carried out intensively, in detail, and in depth on an organism (individual), institution, or certain symptoms in a limited area or subject (Gunawan, 2013). Qualitative research can also be defined as research that generates discoveries that cannot be achieved through statistical procedures or quantitative methods (Choiri, 2019). In this method, certain cases are selected and determined to be the object of research. In this study, the authors utilized two types of data sources, namely primary sources and secondary sources. Primary data sources are sources that provide direct data to data collectors (Sugiyono, 2006). In this study, the primary data source was obtained from interviews. Secondary data sources, on the other hand, do not provide data directly to data collectors, but through other intermediaries or documents (Sugiyono, 2006).

This research was carried out at SMAN 1 Kalijati, which has consistently applied this learning method during the pandemic period from 2020/2021 to the 2021/2022 school year. The implementation of the STEM-based PJBL approach in this school involves strategic subject collaboration, so that the results of this study can be used as a reference by other schools. The STEM-based PJBL approach is used to overcome learning difficulties that generally occur conventionally during the Covid-19 pandemic. The data collected in this study was to obtain accurate and precise sources of information through several methods, including: Observation: Researchers observed learning activities recorded by the school, then confirmed with the relevant teachers and school principals. Observations focused on lesson plans, STEM-based PJBL learning steps, patterns of student collaboration, collaboration systems, ways of motivating students, student activity and creativity, student project results, how students communicate project results, and assessment design.

In-depth interviews were conducted with 1 principal, 5 teachers and 10 students involved in this learning program. Interviews were conducted during the teaching process and after learning was completed.The purpose of the interview was to validate the findings from observations regarding the syntax and learning strategies of STEM-based Project Based Learning. Document review: A review of documents relevant to the research is carried out. Triangulation: Triangulation of data is carried out by comparing the results of observations, interviews, and document reviews. By using these methods, this study aims to gain an in-depth understanding of the implementation of STEM-based PJBL learning at State Senior High School 1 Kalijati.

RESULT AND DISCUSSION

Learning is the teacher's job to manage and guide students to experience changes for the better (Siddik, 2006). Corey was quoted by Syaiful Sagala explaining, learning focuses on efforts to condition the environment so that other people follow it or other people respond to it under certain conditions (Sagala, 2013). Dimyati and Mudjiono, learning comments regarding teacher activities that are structured in instructional patterns, so that students are active in learning (Dimyati, 2014). Law number 20 of 2003 means that learning involves interactions between teachers and students, as well as learning resources in certain environments. These five definitions show that learning is a situation created by educators or teachers to facilitate the student learning process. In an effort to stimulate student learning, various learning designs have been made, one of which is the Project Based Learning model, also known as Project Based Learning (PjBL). Project-Based Learning is a type of learning that emphasizes solving real problems that occur every day. Gijbels (2005) states that Project Based Learning refers to a contextual approach to instruction that uses a lot of concrete-based learning and teaching. Focus on concrete problems that are the beginning of the learning process is central to most definitions of Project Based Learning (Gijbels, D, Dochy, F dan Van de Bossche, 2005). With PjBL, there is an inquiry process starting with asking questions that lead and lead students to engage in collaborative projects that identify various themes (content) of the curriculum as well as in-depth investigations of real-world topics that will be valuable for students' attention and efforts (Kemdikbud, 2014).

According to Perrenet cited in Mills and Treagust, the differences between PjBL (Project-based Learning) and PBL (Problem-based Learning) can be explained as follows: 1) Compared to PBL, PjBL requires a relatively longer project completion time by students. 2) PjBL emphasizes the application of knowledge, while PBL focuses more on students' mastery of knowledge. 3) PjBL generally involves multiple disciplines,

whereas PBL focuses on one or a few disciplines. 4) Time management and information sourcing are more crucial in PjBL compared to PBL. 5) Self-direction, or the ability to guide oneself, is more prominent in PjBL compared to PBL (Mills & Treagust, 2003).

The five criteria of project-based learning (PjBL) are Centrality, Direct Questions, Constructivist Inquiry, Autonomy, and Reality: 1) The projects hold a central position, rather than being peripheral to the curriculum. 2) PjBL projects focus on problems that drive students to learn the core or main concepts and principles of the discipline. 3) Projects engage students in constructivist inquiry. 4) The projects are partially student-driven. 5) The projects are realistic, unlike typical schoolwork.

The main characteristic of the Project Based Learning (PjBL) learning model is that this model is designed to solve complex and complex problems. Students are required to make observations, explorations, trials, and innovative activities to solve these problems. In the PjBL model, students experience a contextual learning process, which is directly related to everyday events and tries to solve problems, especially complex ones. There are five learning criteria that make up PjBL, namely Centrality, Direct Questions, Constructivist Inquiry, Autonomy, and Reality. Several stages of PjBL were developed by The George Lucas Education Foundation and Dopplet. The PjBL syntax consists of six phases, namely: (1) Determining Basic Questions (Start with Essential Questions), (2) Developing Project Planning (Design Project), (3) Developing Schedules (Create Schedule), (4) Monitoring Students and Progress Project (Monitoring the Students and Progress of Project), (5) Assess the Outcome, and (6) Evaluate the Experience (Kemdikbud, 2014). PJBL initiatives collaborate a lot with other systems, one of which is the term STEM, which is a popular learning model in the world that effectively implements integrated thematic learning, because it combines the four main fields of education, namely Science, Technology, Mathematics. STEM was first used by the NSF (National Science Foundation) in 1990, which became an acronym for Science, Technology, Engineering and Mathematics. STEM is an interdisciplinary learning approach between Science, Technology, Engineering and Mathematics (Kevin Adhelacahya, Awalinda Adji Nur Said, 2020). Science (Science): This is the part of science that studies the universe, its facts, phenomena and laws of existence (Simpson, 1963). (2) Technology: created as an innovation, change, and transformation of the natural environment to meet human needs and desires. Technology aims to change the world to meet human needs (3) Engineering (Engineering): consists of asking, imagining, planning, creating, and improving. Engineering is an activity in which scientific and mathematical knowledge is obtained or applied through research, experimentation and practice to operate or design programs to solve problems to meet the needs of human life. (4) Mathematics (Mathematics): A branch of science that studies patterns or relationships (Mulyani, 2019).

Project-based learning (PjBL) is a recommended instructional model in the 2013 curriculum, while STEM is more of a broader strategy (Rahmania, 2021). PjBL has its own specific steps, different from PjBL integrated with STEM (referred to as PjBL STEM here). The characteristics of PjBL and PjBL STEM are similar, but PjBL STEM places greater emphasis on the design process. The design process is a systematic approach to developing solutions to problems with well-defined outcomes (Robert M. Capraro, Mary Margaret Capraro, J. Morgan, 2013).

It was concluded that active learning is a learning approach that provides opportunities for students to play a more active role in the learning process (searching for information, processing information and concluding it, to then apply it) by

providing a learning environment that makes students not depressed and happy (Sivan et al., 2000). According to Satiadarma, creativity is one of the assets that must be owned by students to achieve learning achievement. Student creativity should not be interpreted as the ability to create something completely new, but the intelligence possessed by students in viewing provisions where guidance and understanding are still needed (Sutomo, 2017). Some creative personality traits are: 1) Deep curiosity, 2) Frequently asking good questions, 3) Giving lots of ideas, 4) Free in expressing opinions, 5) Having a deep sense of beauty, 6) Having a sense of broad humor, 7) Having imagination and 8) Original in expressing ideas. 9) Stand out in one of the fields of art (Munandar, 2009). Creative learning is a learning process that requires teachers to be able to motivate and bring out students' creativity during learning (Manurung, 2012). Creative learning is intended for teachers to create a variety of learning activities, so as to meet the various levels of student abilities. Students are said to be creative if they are able to do something that produces a new activity obtained from the results of creative thinking by making it happen in the form of a new work (Sutomo, 2017).

STEM-based Project Base Learning learning has the power to encourage students to have knowledge and understanding of the material presented and to have intellectual intelligence on the subjects they study, but to be able to motivate and develop the characters that are expected to be internalized in the nation's children, namely active and creative characters.

Enthusiastic attitude to student learning

Student enthusiasm is quite good with the implementation of PJBL-STEM, this is summarized in the results of interviews with school principals, teachers and students.

Table 1. Interview Result

No	Respondent	Interview result
	Headmaster	*Students' enthusiasm for learning using the PJBL-STEM pattern is quite good, when online the average student wants to open the screen, because they have lots of things to ask, likewise during offline learning, students actively ask questions, they are interested in their project assignments, their presence is quite good, active asking questions, commenting, completing assignments well and when solving project problems, the children were quite enthusiastic.*
	Teacher 1 and 2	*Teacher 1* *Students' enthusiasm for learning using the PJBL-STEM pattern is quite extraordinary, they are responsible for their assignments so they ask a lot of questions, when they are online they actively attend, ask questions, comment, complete assignments well and are enthusiastic when completing projects.* *Teacher 2* *PJBL learning that is stem-free brings changes to students, their activity and creativity increases, they are used to asking questions, answering and commenting on problems that arise in class when projects are completed.*
	Student 1 and 2	*Student 1*

		Learning through projects made me and my friends have to do a lot of digging and looking for answers so that the projects we created would be answered quickly. We had a lot of discussions and asked questions to the teacher. *Student 2* *Yes, with the existing project, we are quite motivated to look for answers and ask a lot of questions and look for various steps to go to the library, ask teachers and so on so that the project can be completed quickly.*

Paying attention to the three components interviewed above, it appears that the principal sees something positive that students do when completing a project, their enthusiasm and attention is quite good, the students' courage to ask questions and make comments shows that they have a serious desire to learn and solve problems. This is confirmed by the teacher's statement that the students are quite active in collaborating looking for ideas to complete their projects and in essence the students want the projects to be completed on time and in accordance with the provisions. This condition shows that with the help of the PJBL-STEM learning system, students have the courage to express opinions, answer and be creative in finding new ideas for completed projects. The following is a picture of students who were active in class when implementing PJBL-STEM learning at school.

Figure 1. Enthusiastic Students Prepare Tools And Materials For The Project

Students actively divide tasks to obtain various tools needed for their research projects. The enthusiastic attitude of students studying students is described from their presence during online learning. Distance learning, which was still in effect at that time in 2021, has been utilized by teachers and students to the fullest. At the beginning of online learning, many problems arose related to the static conditions of students, as found in State Senior High School 1 Kalijati Subang before the Base Learning Project was implemented, student participation in the display layer was included in the average category of less than half, even the opinions of teachers and students. students choose not to display their screens during online learning. When compared between before and after STEM-Based PJBL was applied the enthusiasm of students was

different, both for appearing on the screen, attendance, asking questions, answering, or commenting, according to the responses from teachers and students as many as 10 teachers and 7 students obtained data:

Table 2. Students' Enthusiastic Learning Attitude

No	*Student Enthusiasm for Online Learning Period*	*Before*	*After*	*Ascension*
1	Display Face Screen	47,90%	64,71%	16,81%
2	Presence	64,71%	71,43%	6,72%
3	Ask	36,13%	60,50%	24,37%
4	Reply and Comment	42,02%	52,94%	10,92%
5	Comment and Answer in WA	56,30%	62,18%	5,88%
6	Completing the task	50,42%	75,63%	25,21%
7	Engage in Problem Solving	47,90%	72,27%	24,37%
Rata-rata		345,38%	459,66%	114,28%
		49,34	65,67	16,33%

Source: teacher and student data mining

The data indicates that student activity and creativity is measured by the enthusiasm of students participating in online learning, there is an increase after the STEM-based Project Base Learning learning is implemented. There was an increase of around 16.33%, if it was categorized as before the implementation of PJBL-STEM the average was less than half of the students were enthusiastic and after BJBL Most of the students were enthusiastic in learning after the PJBL-STEM program was implemented.

Student Creative Ideas

Students' creative ideas can be explored if students discuss and collaborate a lot in project groups because in this position students will be motivated to find answers and complete assignments. The following are the results of the interview to what extent students' creative ideas emerged when PJBL-STE was implemented.

Table 3. Interview Results

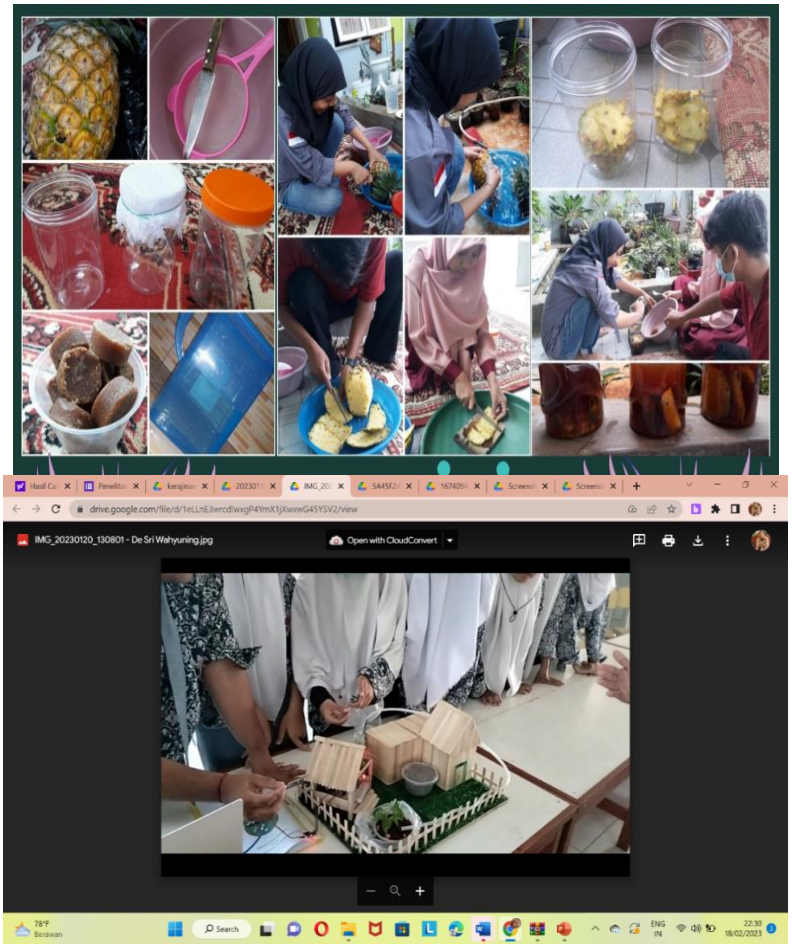
No	Responden	Interview Results
	Headmaster	*The results of each project completed by students are quite diverse, so that the results of the projects vary according to the group's ideas. It can be seen in the presentation of their results that they explain the flow of different ideas according to the projects they make.*
	Teacher 3	*When studying Biology with PJBL-STEM, the students were quite active and the groups that completed the assignments were quite rich in ideas, the results were mixed. Each group creatively conveyed solutions to the projects they created, even the results of the presentations presented were quite creative.*
	Student 3,4	*Student 3* *The project that we have to complete really motivates us to look for new ideas which we continue to look for via the internet and in consultation with teachers. This*

		is done because we have to be aware and accountable for the results. *Student 4* *With the project given, we in the group will try to find the maximum idea so that the task is different from the others and we in the group will be responsible for the results of the project..*

If you pay attention to the three components interviewed above, it is clear that students are brave in conveying new ideas through the projects they have to complete. Creative ideas emerge when faced with problems that must be solved, and the main problem is that students have to find ideas that are different from other groups. Apart from that, students' ideas and initiatives emerge because they are motivated by other friends in the group and outside the group, they look for and look for other ideas that are different towards the goals and results of the projects they create. This condition is an illustration of what the principal, teachers and students convey regarding students' creative abilities. Apart from that, ideas that emerge collaboratively show that there is comprehensive responsibility for students so that their project assignments are completed optimally according to the agreed terms.

The following picture shows students are active in conveying their ideas in group discussions:

Figure 2. Students' Pictures Collaborate to Produce a Product Work of Art



One indicator of active and creative students is that there are products produced and product creativity that appears after the teacher gives project assignments. Seeing the condition of students related to the product produced, of course, also looks at the extent to which the task has been completed and the model of the completed task. There are several things that can be used as standards in viewing this aspect as a measure of active and creative students, namely the number of assignments completed, the type of assignments made and the results; collected productsFigures and tables are the most effective way to present results. Captions should be able to stand alone, such that the figures and tables are understandable without the need to read the entire manuscript. Besides that, the data represented should be easy to interpret.

Table 4. Student Creativity Ideas

No	Student Creative Ideas	Before	After	Ascension
1	Convey New Ideas	40,34%	72,27%	31,93%
2	Presenting Task Results	42,86%	78,99%	36,13%
3	Initiative Idea	36,97%	70,59%	33,62%
4	Critical students dare to express opinions	39,50%	69,75%	30,25%
5	Students Have Initiatives When Learning Online	43,70%	71,43%	27,73%
6	Solve open problems, have initiative	38,66%	70,59%	31,93%
	Amount	242,03%	433,62%	191,59%
	Average	40,34%	72,27%	**31,93%**

The results of the comparison table above concluded that on average there was an increase in student activity and creativity after implementing STEM-based Project Base Learning learning, and the average change was 31.93% or nearly 32%, meaning that the role of learning design was very help in encouraging students with character. Project-based learning and STEM implementation can motivate students to be more active and creative in learning.

Learning Convenience

One of the efforts to get new ideas from a positive activity is in a happy, happy and comfortable state of mind and soul. Comfort is important for students when learning because learning is pleasing with openness of heart and mind, therefore measuring the power of creativity that appears can be measured from the level of comfort in doing assignments or completing learning assignments, along with the power of activity and creativity of students when students are involved before and after the implementation of the Project. STEM-based base learning at State Senior High School 1 Kalijati Subang, online learning period.

Table 5 Students' Comfort during Learning

No	Comfort in Learning	Before	After	Ascension
1	Students are engrossed in learning to do assignments	42,02%	70,59%	28,57%
2	Students Have	41,18%	71,43%	30,25%

	Perseverance when learning online			
3	Students Enjoy Finding New Experiences.	37,82%	75,93%	38,11%
4	Students are sensitive, energetic and confident	40,34%	69,75%	29,41%
	Amount	161,36%	287,70%	126,34%
	Average	40,34%	71,93%	31,59%

The comfort of learning really helps students to be more active and creative because with comfort students are able to generate self-motivation. The conclusion above is STEM-project-based learning, an increase of 31.59%. The most visible improvement is in the persistence of completing the project. It becomes the dominant thing because persistence is the main subject of completing assignments, those who do the tasks during the project are related to reports that must be made, presented and accounted for. Everything becomes student motivation, they worry if their assignments are not completed. In addition, grouping students for each class raises competitiveness so that each member of the group will try to get the best project results.

The most visible increase was in the activity of solving problems, persistence in participating in online learning, maximally students followed, there was a tendency for students not to want to be left behind, the increase in this index reached 30.25%. And the highest is in the condition of students who enjoy getting new experiences which increases to 38.11%.

Table 6 Interview Results

No	Responden	Interview Results
	Headmaster	*When I observed the teacher in class, the students seemed to enjoy learning, asking questions without burden regarding the project they had to complete. Each group worked diligently in discussions, they confidently sought various answers and solutions from the projects they completed.*
	Teacher 4	*There is something interesting about this STEM-based PJBL learning, namely that students diligently enjoy the assignments given, discussions are held with friends in their groups, they look for lots of ideas and experiences from new members to complete their assignments. Students even confidently ask and answer questions during class discussions or group discussions.*
	Syident hal 5 dan 6	*Student 5* *In project-based learning, I was quite comfortable because I was helped by friends who were active in solving problems, I even got a lot of new experiences, namely I had to look for new ideas that were different from other groups, I even had to work hard to complete assignments that would later have to be presented, p. this has been an extraordinary experience for me.*

		Student 6 *When studying various projects, assignments are shared with friends, we are not embarrassed to discuss and look for solutions, we will even help each other with difficulties, together we can complete assignments well.*

If you pay attention to the three components interviewed above, several things emerge that are the basis for students feeling safe and comfortable learning in the implementation of PJBL-STEM, namely, students are engrossed in doing assignments, this condition is related to the values of tenacious character which are naturally internalized in students, Without realizing it, students in their groups complete their assignments without feeling any pressure, therefore students' persistence in learning in PJBL-STEM activities is no longer in doubt. Apart from that, in the implementation of BJBL-STEM, students feel that they have gained a new experience, namely that there are systematic activities that students must complete through scientific methods, use of technology, measurable and accountable, this experience makes students understand more about the meaning of a task that must be completed naturally and measurable. Positive new experiences that are built on repeated controlled and systematic activities make students more confident and confident that what they complete in the project can be accounted for.

Table 7. Example : Student Activities and Creativity
in Completing Projects Making Decorative Crafts Using Resin Art Techniques

No	*Title, Group, Materials and Activities*	*Creative Products*
1	Title	***Making Decorative Crafts Using Resin Art Techniques***
2	Group	Group 1 Class XII Science 3
3	Ingredients used	Digital scales, hanging ring, resin mold, sandpaper, plastic spoon, plastic cups Resin liquid, Catalyst fluid, liquid prevents bubbles
4	Prepare materials and tools	
5	Process	1. Pour and stir the residual liquid and catalyst into a plastic cup then measure in a 1:2 ratio. 2. Measure using the scales that have been prepared.
6	Process	To make the hanger, use 10 grams of liquid resin and 5 grams of catalyst and to make necklace pendants, use 8 grams

		of liquid resin and 4 grams of catalyst For frames, use 30 grams of liquid resin and 15 grams of catalyst 
7	Process	After measuring and weighing, add 3 drops of anti-bubble then stir 
8	Process	pour the resin into the mold that already contains the flower 
9	Results	let it dry and harden then lift it from the mold and attach it to the ring and necklace 
10	Report	***Video and Power Point***

Source: Collaboration Class Project 1 XII Mifa 3 SMAN 1 Kalijati Subang

The table describes students' activities while completing STEM-based projects. Students are busy with various activities and creativity because they are motivated by projects that must be completed according to the specified time and material deadlines.

Competency enhancement

Three things become a benchmark in determining active and creative students based on increasing students' competence, namely: discussion based on teacher instructions; Think elaboration skills, hard skills, soft skills and the ability to evaluate works. The first indicates that what students do does not dare to violate the procedures determined by the teacher. Students discuss, solve their problems while following the specified steps, so that the competence of students is controlled through the teacher's directions and instructions. The second is related to the ability to elaborate on hard skills and soft skills. The intelligence of students is supported by their understanding and skills which are internalized in their attitudes and behavior, these competencies are trained through this Project-Styem based learning. And third with regard to the ability to evaluate his work, is the ability of students to understand and evaluate a work, in the process students will try to get experience and information in assessing a work so that the work made is truly optimal. The following are the opinions of teachers and students regarding increasing student competence:

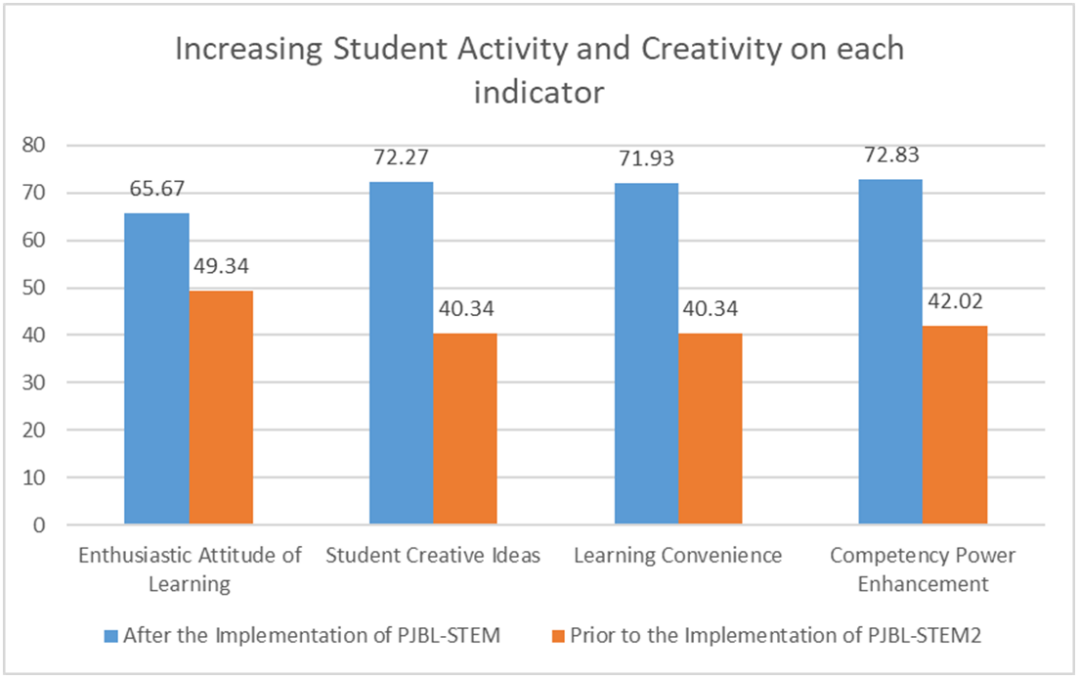
Table 8. Increasing Student Competency Power

NO	Student Competency Power	Before	After	Ascension
1	Discussion based on the teacher's instructions	41,18%	76,47%	35,29%
2	Think elaboration skills hard skills soft skills	42,86%	72,27%	29,41%
3	Able to evaluate work	42,02%	69,75%	27,73%
	Amount	126,06%	218,49%	92,43%
	Average	42,02%	72,83%	30,81

Source: Teacher and Student Responses

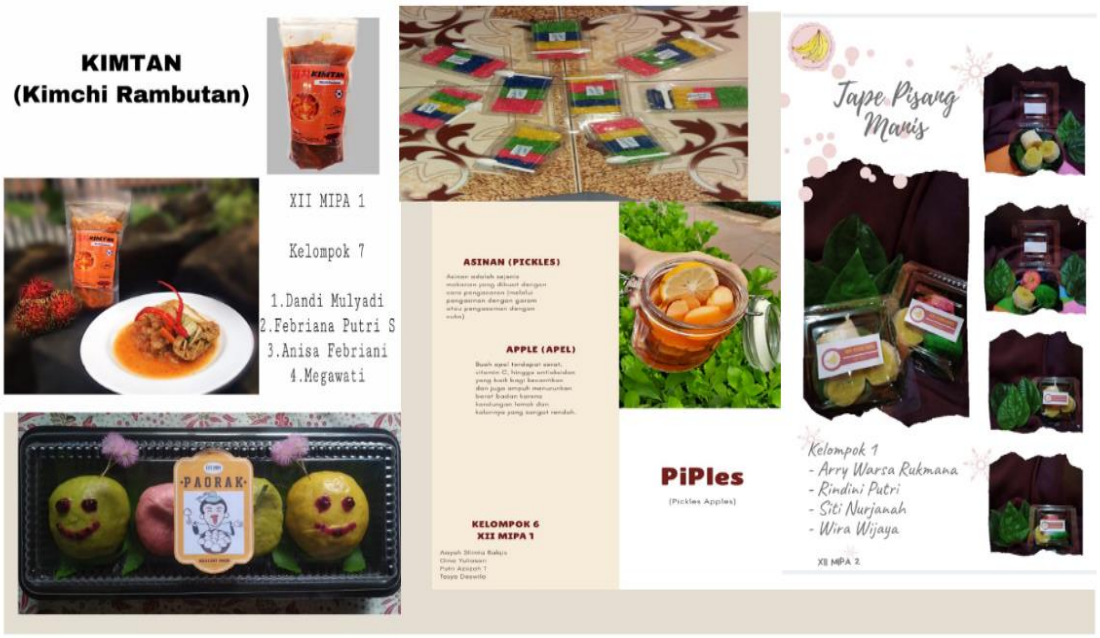
The table explains that there is an increase in the activity and creativity of students in their ability to follow the teacher's instructions during discussions reaching 35.29%. This figure is the highest. The calculations obtained reached 30.81%, meaning that student activity and creativity increased based on active and creative indicators during the online learning period with the implementation of STEM-based Project Base Learning at State Senior High School 1 Kalijati Subang. Four characteristics of increased activity and creativity are constructed based on indicators of student activity and creativity. Each consists of their respective levels of achievement. The following is a graph of the increase in student activity and creativity before and after the implementation of STEM-based Project Base Learning learning.

Figure 3 Results of Interviews and Observations at State Senior High School 1 Kalijati Subang



Project-based learning can be carried out in all situations and forms of learning in schools, both online and offline learning. Some teachers have implemented this learning to provide motivation so that learning is more interesting and fun, but the conditioning of the implementation is coordinated by the school, namely by integrating various subjects, so project productivity and the quality of the results completed by students are more diverse, more conditioned because the responsibility for completing assignments is focused on several subject teachers, each of whom can control the projects students work on. Following are several products resulting from the implementation of PJBL-STEM at SMAN 1 Kalijati Subang.

Figure 4. PJBL-STEM Products for SMAN 1 Kalijati Subang



The images are the results of students' work after the PJBL-STEM based learning process carried out at SMAN 1 Kalijati. There are three real products produced after the children collaborated, namely Kimchi rambutan, Asinan, replace and other packaged products, a combination of various kinds. parliamentary system according to the materials that have been taught, Project-based learning leads to student activities producing products according to plan, products become an inseparable part of efforts to make children more active and creative.

In this Project-based PJBL integrated learning there are several targets that must be completed by students and continue to be supervised by the teacher, namely in process activities, gathering materials, providing solutions and expected products. In addition, the responsibility and enthusiasm of students is stronger because each group not only has to submit assignments but also has to present and be accountable for their products in front of all subject teachers, including in front of their fellow classmates (English & Kitsantas, 2013). This condition coincides with the teacher's enthusiasm in preparing worksheets and student control, they are dealing with material that must match a predetermined theme, are able to provide interesting projects and can prove their work.

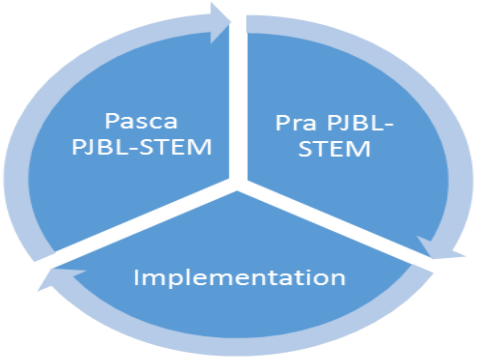
Integrative learning according to Fogarty is a type of integrated learning that uses an approach between fields of study, combining fields of study by setting curricular priorities and determining skills, concepts and attitudes that overlap in several fields of study (Trianto, 2012), other experts say the integrated model (integrated) is the integration of a number of topics from different subjects, but the essence is the same in a particular topic.

There are several indications that the BJBL-STEM integrative learning process shows that it encourages students to be active and creative, namely: first, there are several subjects that are combined; secondly, there are comprehensive topics or themes that are relevant to each basic competency in each subject so that they form a single unit in a project; Third, each project that is done and completed leads to one project, but the product will be related to other subjects, according to the existing worksheet (Tirka, 2021). The three main analyzes that were processed in this study were aimed at extracting data on student creativity activities before PJBL-STEM was implemented, implementation of learning and student activities and creativity after the implementation of PJBL-STEM both during the Covid 19 and post Covid 19 periods, using an online model.

Constructing learning activities that are integrated or integrated between subjects, built through a project approach to the STEM pattern, specifically, science seeks answers with scientific analysis, finding out with observation, document review and even interviews. Then the project work intersects with efforts to use the tools that are around students in the form of technology that can be utilized to solve their problems. Engineering is concerned with engineering the stages of completion of the task which are carried out systematically and sequentially and finally mathematics, a concept that involves calculation patterns and symptoms of interrelationships between variables in a project.

There are three major steps in fulfilling STEM Project-based learning that has been implemented at State Senior High School 1 Kalijati Subang, namely Pre-PJBL-STEM Learning activities, Implementation and Post-PJBL-STEM, this can be seen in the following figure:

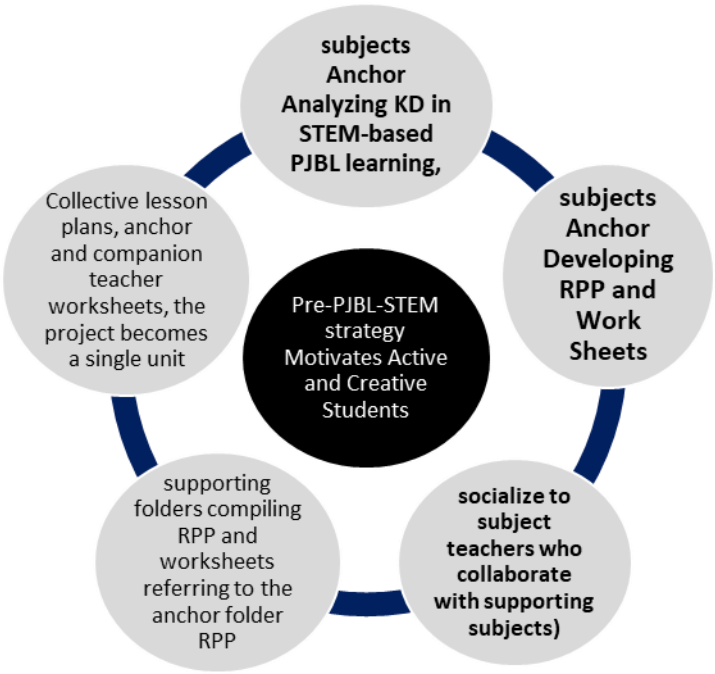
Figure 5. Stage 1 of the PJBL-STEM Strategy



Pre Learning Stage

At this stage the teacher prepares various learning tools that are relevant to the theme or relevant to other subjects as companions. Following are the stages in pre-learning activities:

Figure 6. Picture of PJBL-Stem Pre Learning Stage



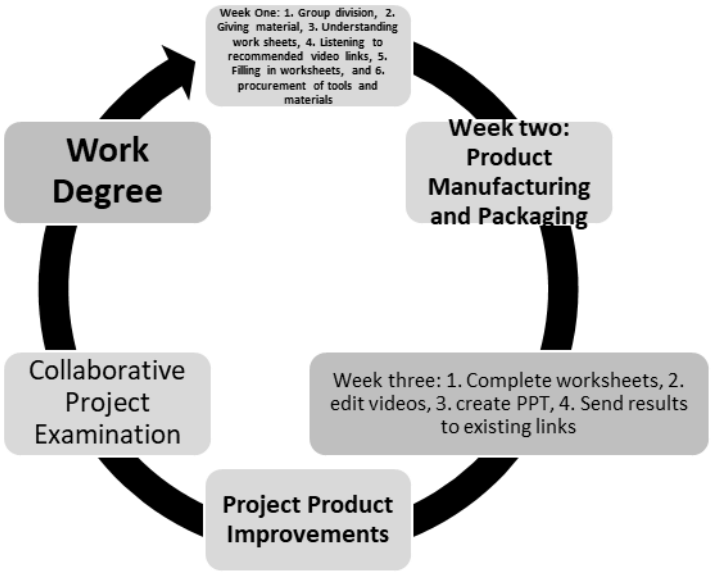
The picture above leads to the readiness of teachers to teach by making collaborative plans between subjects by compiling collaborative Learning Implementation Plans. This situation occurs multidisciplinary integration. Namely without combining the Basic Competencies of each subject so that each subject still has its own Basic Competency. The anchor subject teacher analyzes the Basic Competencies that can be carried out through STEM-based learning, determines the type of projects (tasks) to be given to students, the Anchor subject teacher prepares a Learning Implementation Plan and worksheets, The anchor subject teacher socializes the lesson plans and worksheets that have been prepared to the subject teachers who collaborating (supporting subject matter), supporting subject matter compiling Learning Implementation Plans and worksheets referring to worksheets and Learning Implementation Plans anchor subject. The anchor subject teacher and supporting

subject teachers discuss collaborative projects, combining Learning Implementation Plans, worksheets, and assignments/projects from the collaboration group into one unity.

Implementation Stage

The second stage in the BJBL-STEM strategy so that students are active and creative is the implementation of the RPP that has been made, the following are the stages in implementing PJBL-STEM in class according to the predetermined schedule:

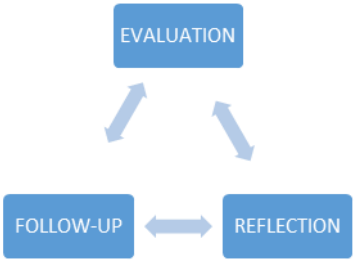
Figure 7. PJBL-STEM Implementation Stage Picture



In the picture it is explained that the next stage after the pre-learning process is the implementation stage. This stage is conditioned according to the schedule, every week students receive assignments according to their progress. The first week is the main week for classifying and categorizing project tasks, including group division activities, providing materials, understanding work sheets, listening to recommended video links, filling in worksheets, and procuring tools and materials. The second week is making products and packaging, the third week is completing worksheets, editing videos, making PPTs, and sending the results to the link. The fourth week is product improvement and the fifth week is a trial, meanwhile in the sixth week a work is held.

Post PJBL-STEM Stage

At the PJBL-STEM implementation stage, after the activity is completed, evaluation, reflection and follow-up are carried out in the form of reports, dissemination of team work results through subject collaboration teams. The following describes the stages after PJBL-STEM is carried out:



The evaluation stage is the final stage after the PJBL-STEM implementation is carried out, which includes providing assessments and input on student products. In this section the teacher is preoccupied with assessing student work as a continuation of the assessment process. Each group will be assessed by all teachers collaborating on their subjects.

The Reflection Stage is the evaluation stage between teachers regarding the subjects or projects that have been delivered both in terms of material, activity, creativity and the benefits of projects that have been completed by students. During this period, there will be a project evaluation process so that it is identified which materials or projects can be continued or replaced with other more relevant projects. The reflection stage usually continues with follow-up activities, among others, filled with IHT as a forum for teacher dissemination, conveying good practices to teachers others so that it can be used as a benchmark and standard for further learning development, especially with regard to the implementation of STEM-based PJBL at State Senior High School 1 Kalijati, Subang. In addition, the approach used is an interdisciplinary, interdisciplinary approach. Intradisciplinary integration is carried out by integrating the dimensions of attitudes, knowledge, and skills into a unified whole in each subject.

DISCUSSION

The main finding in this research is that students' activity and creativity emerge through learning based on Project Base Learning (PJBL) in the STEM framework which leads to a multidisciplinary learning function, there is a combination of material in the project, each combined lesson has its own Basic Competency which leads to one main theme (Calavia et al., 2023). The integration pattern built in learning intersects with a spider web learning model, namely an integrated learning model using a thematic approach. This approach's development begins with determining a theme. The figure who developed this model was Lyndon B Johnson. The difference that is built in these findings is that the subjects that collaborate make learning plans each lead to one theme. Integrating subjects continue to collaborate until the project is complete. Three big steps in fulfilling STEM Project-based learning, namely. Pre-Learning Stage, At this stage the teacher prepares various learning tools that are relevant to the theme or relevant to other subjects as companions. Implementation Stage. Conditioned according to the schedule, every week students receive assignments according to their progress. Post PJBL-STEM stage, namely the implementation of PJBL-STEM, after the activities are completed, evaluation, reflection and follow-up are carried out in the form of reports, dissemination of team work results through subject collaboration teams. Research entitled The influence of the Project Based Learning (PjBL) model with a scientific approach assisted by outdoor study on social studies learning outcomes (study of class VIII students at SMP Negeri 2 Tuban) Masters thesis, State University of Malang, the results of the research show that from the two classes carried out experiments and comparisons The results showed that there was no significant difference between PJBL learning and the scientific approach assisted by Outdoor Study, but the students' activities looked more enjoyable and they were more enthusiastic about learning. Different from what will be researched, it encourages students to be creative and responsible for their assignments (Sukma, 2017). Through the integration of several subjects in one theme or one project. Research conducted by Maria Dona Reza Usboko1, I Made Parsa2, and Zet Y. Baitanu3 123 Electrical

Engineering Education Study Program, FKIP, Univ. Nusa Cendana entitled Application of STEM Learning with the PJBL Model in Class The three relevant studies above describe the absence of efforts to explore the research system that leads to a collaborative process between subjects that produces certain characteristics.

In its implementation, this project relates to curriculum targets, available time, teacher readiness, lesson schedules and school management systems. Therefore, it requires a systematic process in its implementation. Curriculum targets can be adjusted through selecting material that is relevant to the subject. Available time can be adapted to special scheduling. Teacher readiness needs to be trained first and the management system can be adapted to set accurate schedules. This alternative solution is certainly not easy to implement without the cooperation of all the academic community at the school. The gaps found are part of what the school can work on, the most important thing is to focus on efforts to continuously improve the quality of students, including efforts to develop active and creative characters.

The implications of the research results point to the duties and responsibilities of school management, school principals need to create a design to condition collaboration between subjects in the school, which has consequences for the lesson schedule. And those who are also affected by the implementation of the results of this research are teachers, their competence needs to be improved in the aspect of the ability to choose material that is in line with the chosen theme in collaboration. Apart from that, the effect is that teachers must be skilled at making projects that motivate students to be active and creative, as well as the need for facilities and media. Prioritize so that the project is created according to expectations. Apart from that, synergy between schools and parents also needs to be a priority in order to support the realization of projects that are being created, especially financial support and guidance in the time available outside of school.

Research is revealed based on what teachers have done in class and submitted for analysis. Due to time constraints, research results need to be taken up and explored and developed more deeply. Apart from that, the results of this research will be more accurate if it is expanded by conducting experimental research to test the accuracy of an integrated learning model in subjects to develop active and creative characters. And it can be further developed by future researchers.

CONCLUSION

Based on the function of STEM-based Project Base Learning learning which can improve the active and creative character of students at State Senior High School 1 Kalijati Subang, the research results concluded that the integration of learning consists of several stages. First, the pre-learning stage where several subject teachers collaborate to prepare various tools relevant to the theme. Second, the implementation stage where students are given responsibility for completing the project for several weeks, starting from classifying project tasks, dividing groups, providing materials, to sending the results to the link provided. Third, the post-learning stage where evaluation and follow-up, reports and subject collaboration team dissemination are carried out. As a result, this learning succeeded in increasing student enthusiasm in learning, student creativity, learning comfort, increasing competence, and student project products.

STEM-based Project Base Learning learning at State High School 1 Kalijati Subang encourages student activity and creativity in a positive way. It can be seen from the enthusiasm of students' learning, students' creative ideas, learning enjoyment, increased competence, and student project products. Therefore, there are several

recommendations from the results of this study to improve student character through learning strategies. Principals need to motivate and encourage teachers to be more active and creative in developing learning in the classroom. Teachers as the spearhead in providing education to students, need to continue to build themselves with various creative and innovative dynamics and understand various strategies, methods and techniques so that they are always up-to-date and can adapt to student developments and the times.

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