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The Implementation of PBL-STEAM Equipped with JBatik Software as Learning Media to Enhance Students' Creative Thinking Skills in Designing Batik Motifs of Indonesian Local Heritage

Sumardi
Department of History Education, Faculty of Teacher Training and Education, University of Jember, Indonesia Jl. Kalimantan 37, Jember 68121

ABSTRACT: The aim of this research is to analyze the student's creative thinking skills under the implementation of the Problem-Based Learning Model equipped with JBatik software. This study used a quantitative approach with a quasi-experimental design: pretest-posttest non-equivalent group design. The research respondents consisted of two classes: the control class with 31 students and the experimental class with 29 students. The research instruments used were interviews, questionnaires, observations, and creative thinking tests. Data analysis techniques used a one-way ANOVA test, LSD post hoc test, and independent sample t-test. The one-way ANOVA test results showed a sig value of 0.000 < 0.05, indicating a significant influence of applying the Problem-Based Learning Model Integrated with Information Technology on independence. The LSD post hoc test showed a mean difference between the experimental group of 9.600 and the control group of 5.067. The results showed that based on the independent sample t-test analysis on the post-test, there was a significant difference between the control class and the experimental class. It is due to the sig (2-tailed) score is 0.002 (p = <0.05). The qualitative analysis shows all the Pearson Correlation Coefficient values are less than 0.7. Based on this, there is no significant similarity between the interviews Thus, it can be concluded that the experimental group taught using the Problem-Based Learning Model Integrated with Information Technology has a better effect on independence compared to the control group taught using the Problem-Based Learning Model-STEM.

KEYWORDS: Creative Thinking Skills, JBatik, Learning Media, Problem-Based Learning, STEAM.

1. INTRODUCTION

Creative thinking is the ability to generate innovative and original ideas. It involves the capacity to see problems or situations from different perspectives, think beyond conventional boundaries, and combine unexpected concepts (Csikszentmihalyi, 1996). Creative thinking plays a crucial role in various aspects of life, such as art, business, education, science, and personal development (Amabile, 1993). Creative thinking plays a primary role in the process of innovation. With the ability to think beyond limits, people can discover new solutions, new products, or new approaches to a problem. As Steve Jobs, the founder of Apple Inc., stated, "Creativity is just connecting things." Creative thinking helps in finding more effective and efficient solutions to the problems at hand. Through creative thinking, individuals can identify new alternatives, formulate unconventional strategies, and discover innovative approaches to overcome challenges. Creative thinking also contributes to personal development. By practicing creative thinking, individuals can train their imagination, flexibility of thought, and ability to overcome mental barriers. This helps enhance adaptability, open new opportunities, and boost self-confidence. In a competitive business world, creative thinking can provide a competitive advantage for individuals and organizations. With the emergence of new ideas, companies can develop more appealing products or services, enhance customer satisfaction, and differentiate themselves from competitors. Complex and global problems such as climate change, poverty, and health crises require creative solutions. Creative thinking enables interdisciplinary collaboration and innovative approaches to address these significant challenges, and creative thinking skills are needed in designing the batik process.

Batik is a traditional textile art that has been developed in Indonesia for a long time. Batik involves a dyeing technique where certain areas of the fabric are covered with wax to create specific patterns or designs. This process can be repeated several times with gradual coloring to create more complex and colorful patterns (Larasati et al., 2021). Indonesia has a variety of batik styles originating from different regions across the country. Here is a comprehensive explanation of batik from various regions in Indonesia. Javanese Batik is one of the most renowned types of batik in Indonesia. Regions such as Yogyakarta, Solo, and

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Pekalongan are well-known centers for Javanese Batik production. Javanese Batik typically features intricate patterns with floral, fauna, and geometric motifs. Javanese Batik also often uses vibrant and contrasting colors. Sundanese Batik originates from West Java, particularly the cities of Cirebon and Tasikmalaya (Dhaneswara, 2011). Sundanese Batik tends to have simpler and softer patterns compared to Javanese Batik. Common motifs include leaf patterns, flowers, and animal illustrations. Coastal Batik is a type of batik originating from coastal areas such as Pekalongan, Lasem, and Cirebon. Coastal Batik often combines Javanese and Chinese motifs, as these regions were once international trading centers. Coastal Batik is known for its bright and colorful palette as well as diverse motifs. Madurese Batik comes from Madura Island, East Java. Madurese Batik is characterized by its use of vibrant and contrasting colors. Common motifs include flora and fauna, such as birds and fish. Madurese Batik is also famous for its intricate geometric patterns. Balinese Batik has a unique style and differs from Javanese Batik. Balinese Batik motifs are often inspired by the culture and daily life in Bali. Balinese Batik tends to use soft colors and more abstract motifs, such as orchids, leaves, and deity illustrations. In addition to the aforementioned regions, there are many other areas in Indonesia that have their own batik traditions, such as Sumatra, Kalimantan, Sulawesi, and Papua. Each region has its own uniqueness and distinctive characteristics in terms of motifs, colors, and batik-making techniques. Batik is a valuable cultural heritage of Indonesia and has been recognized by UNESCO as the Intangible Cultural Heritage of Humanity. The beauty and uniqueness of Indonesian batik are renowned worldwide, symbolizing the rich and diverse culture of Indonesia (Steelyana, 2012). The illustration of Indonesia Batik Motifs Shown in Figure 1 below

Figure 1. Batik Motifs from Indonesia as Cultural Heritage

By creating appealing and innovative designs, batik can become a sought-after product not only domestically but also in the international market. This can have positive economic impacts and contribute to the sustainability of the batik industry. The indicators can be presented in Table 1.

Table 1. Indicators of Creative Thinking Skills

Indicator	**Sub-Indicator**	**Explanation**
Fluency	Demonstrate Generate Produce	Creative thinkers demonstrate a high degree of fluency, which refers to the ability to generate a large number of ideas or alternatives. They can produce numerous possibilities and are not limited to a single solution or approach.
Flexibility	Perspective Exploring	Creative thinkers exhibit flexibility by being able to consider different perspectives, adapt their thinking to new situations, and embrace unconventional ideas. They are open to exploring various paths and are not bound by rigid thinking patterns.

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Originality	Original and Unique Fresh Perspective	Creative thinkers tend to produce original and unique ideas. They are not afraid to break away from conventional wisdom and explore unconventional or unconventional solutions. They offer fresh perspectives and often challenge the status quo.
Elaboration	Develop & elaborate	Creative thinkers have the ability to develop and elaborate on their ideas. They can take a basic concept and expand it, adding details, refining their thoughts, and considering potential implications and consequences.
Problem Sensitivity	Identifying	Creative thinkers are adept at identifying problems or challenges. They have a keen sense of observation and can recognize gaps, inefficiencies, or opportunities that others may overlook. They see problems as opportunities for innovation.
Risk-taking	Take risk	Creative thinkers are often willing to take risks and step outside their comfort zones. They are not afraid of failure and understand that experimentation and learning from mistakes are part of the creative process. They embrace uncertainty and are willing to push boundaries.
Originality of Expression	Originality Unique Communication	Creative thinkers exhibit originality not only in their ideas but also in how they express themselves. They may have a unique style of communication, presentation, or artistic expression that reflects their creative thinking.
Curiosity and Inquisitiveness	Asking Question Exploration	Creative thinkers are naturally curious and have a thirst for knowledge. They constantly ask questions, seek out new information, and explore different subjects and domains. They have a genuine interest in the world around them and are always eager to learn.

The 21st-century learning characteristic is learning with digital technology using software (Orak & Inözü, 2021). Digital competencies have transformed traditional learning into a more modern one. There are three types of skills that students must have, including learning skills, literacy skills, and life and career skills (Laar et al., 2017 & (Erdem, 2019). The aspects of life and career skills include time management, leadership, initiative, self-directed learning, and working effectively with others (Ball et al., 2016). The goal is to enable students to have life skills such as adapting to changes, managing goals and time, becoming self-directed learners, working effectively with others, and being responsible to others (Erdem, 2019). One of the most important aspects of 21st-century learning is the ability to learn independently (Mentz et al., 2019). Independence in this context refers to learning independence as a life and career skill that students must have.

In designing batik patterns, graphic design software can be a highly useful tool. While traditional batik patterns are often produced through manual processes using tools like canting, the use of software can assist designers in the pattern design and creative exploration stages (Nurjanah et al., 2020). By using design software, designers can easily create and combine various design elements such as shapes, colors, and patterns. They can experiment with different combinations and variations, allowing them to explore new ideas quickly and efficiently. The Efforts to optimize students' independence are done by improving individual learning abilities and encouraging student growth through the development of active and independent thinking patterns. To achieve this goal, there is a need for a shift in the role of educators (Pradita & Sidik, 2020). Educators in the 21st century are required to create students

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who have soft skills. Therefore, educators play the role of facilitators, guides, supervisors, mentors, and motivators (Sherpa & Bachar, 2018). To carry out all of these roles, educators require more preparation and training, such as teaching skills, mastery of content, and integration of teaching with technology to make learning more efficient and meaningful (Jan, 2017). The emergence of technology integration makes the learning process more conducive, interactive, and beneficial for both educators and students (Hero, 2019). In addition, educators also have a role in encouraging students to become independent learners by developing qualities within students to have a sense of responsibility and independence (Ghavifekr & Rosdy, 2015).

Current students are more familiar with technology such as smartphones and laptops. They can access the information they want directly from their phones (Yılmaz, 2021). Technology can assist educators in facilitating more efficient, interactive, and engaging learning, thus motivating students to learn (Roy, 2019). The development of technology directly or indirectly affects teaching methods. The use of software as part of technology in learning can help educators to use teaching time more effectively, increase resources, and have a positive impact on improving the quality of learning by making it more flexible (Hamiti & Reka, 2012).

The 21st-century students are mostly composed of Generation Z. Generation Z (born between 1995-2010) is a tech-savvy generation (Yu & Suny, 2020). They are technologically advanced and independent compared to the previous generation. Therefore, to maximize student engagement, educators need to strengthen critical thinking skills and change their teaching models (Mosca et al., 2019). Generation Z represents the future of the nation, with Indonesia's golden generation reaching its peak in 2045. Due to the pervasive internet life, issues regarding morality and patriotism arise. Through history lessons, positive inspiration is expected to be produced to counteract characters that are not in line with Pancasila, as well as to instill character-building values so that they become the identity of the younger generation (Rahayu, 2019). Generation Z tends to learn on their own according to their needs (Umamah, 2017). Therefore, history learning in this modern era should convey the essence and essence of history in a new or up-to-date way. History educators must be able to deliver historical material with a more up-to-date teaching approach. Educators are required to make history learning interesting, and therefore, history learning must lead to higher-level thinking, not just memorizing facts without any meaning gained from historical events (Rahayu, 2019). Generation Z is an independent learner who is familiar with the technology. Therefore, educators need to innovate to ensure that learning can run optimally.

The Merdeka Belajar curriculum is a response to the challenges of 21st-century learning (Indarta et al., 2022). The concept of the curriculum is to provide freedom in learning (Sari, 2019). This means providing freedom in achieving the goals, methods, materials, and evaluation of learning for both educators and learners. From this, it can be seen that the learning process in the Merdeka Belajar curriculum is more directed toward the needs of learners (student-centered) (Indarta et al., 2022). Freedom in learning fosters the development of independent character where educators and learners can freely and joyfully explore knowledge, attitudes, and skills from their environment. This can help students grow as individuals, develop care for their learning environment, enhance the confidence and skills of learners, and enable them to adapt easily to the community environment (Daga, 2021). The Merdeka Belajar curriculum provides freedom for educators and learners.

The purpose of history education is to cultivate students' understanding of themselves, society, and the process of the formation of the Indonesian nation through a long and ongoing history that continues into the present and future (Kochar, 2008). In addition, history education plays a significant role in shaping the character, attitudes, and growth of the nation, which is vital in building the Indonesian nation that values national identity, intellectualism, and respect for the struggles of the nation, and a sense of nationalism (Zahro et al., 2017). Therefore, history has a strategic role in shaping the character and civilization of a dignified nation, as well as in forming Indonesian citizens who have a sense of nationalism and love for their country. The history subject has great potential to develop character education (Hasan, 2012).

Through character education, it is expected that students can independently improve and use their knowledge and examine and internalize noble character and moral values so that they are manifested in their daily behavior. Character education plays an important role in equipping students to anticipate future challenges that are increasingly difficult and complex (Zahro et al., 2017:2). The main values in character education include religion, nationalism, independence, cooperation, and integrity. Independent character in character education is an attitude and behavior that is not dependent on others and uses all of their thoughts, energy, and time to achieve dreams, hopes, and aspirations (Kemendikbud, 2017). Character education can be easily achieved if educators have tolerance, innovation, the flexibility of mindset, as well as ingenuity to integrate lesson content and educational goals (Umamah, 2015). Independent character is one of the main values in character education.

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Independence is a process in which individuals take the initiative in researching and formulating their learning goals, identifying sources and learning materials, determining and using learning strategies, and evaluating their learning outcomes (Knowles, 1975). Self-directed learning is necessary for students to develop responsibility, self-discipline, and learning skills. Those who have a high level of independence will strive to take responsibility for their progress and achievements (Jayanti et al., 2019). Some secondary schools have adopted the principle of self-directed learning. Therefore, students are given the freedom to determine the learning activities they want to do and can evaluate their learning with or without the help of educators (Triastuti, 2016). Students need to have self-directed learning skills so that they take responsibility for their learning and are active in the learning process.

Independence is one of the skills that must be possessed by today's students. However, in reality, the independence of students is still relatively low. This is based on previous studies. A study conducted by (Meindrawati, 2017) showed that the classical completeness of independence before the cycle was 47.70%. This indicates that the independence of students is still not good enough. Furthermore, a study conducted by (Wulandari, 2019) showed that student independence reached 54%-56%. This indicates that student independence is still at a low level. Furthermore, a study conducted by (Priyanti, 2019) based on indicators of independence revealed (1) confidence 50%; (2) responsibility 47.36%; (3) initiative 50%; (4) discipline 46.71%. This indicates that the independence of students is still relatively low. The results of the previous studies described above show that the level of student independence is still relatively low. Therefore, this becomes a problem that must be solved in history learning.

Low student autonomy can be overcome by using innovative learning models. One of the innovative learning models to enhance autonomy is the Problem-Based Learning Integrated Technology model. According to Hursen (2019), Problem-Based Learning motivates students to become self-directed learners by using real-world problems. PBL is student-oriented, while educators act as mentors by guiding students to find and solve problems (Z C Cotrunnada et al., 2019). Autonomy can be enhanced through the development of critical thinking skills by increasing creative cognitive activities such as evaluating and proposing ideas, creating problems, and solving them independently (Kopzhassarova et al., 2016). PBL also enhances autonomy by transforming students from passive receivers of information into active learners to develop their knowledge through their own learning experiences based on the problem-solving process (Sugeng & Suryani, 2019). PBL is effective in fostering critical thinking, questioning, problem-solving, and self-directed learning skills (Munawaroh, 2020). Previous studies have shown that Problem-Based Learning improves student autonomy (Kurniyawati, 2019). (Rufaidah, 2020).

Another learning model that can enhance independence aside from Problem-Based Learning is Resource Based Learning. PBL is a suitable learning model to be applied in today's technology-rich learning environment, as it demands students to learn from various available sources using technology, thereby making them actively engaged in various learning resources (Dominggus et al., 2021). Problem-Based learning emphasizes the availability of diverse learning resources, allowing students to independently obtain knowledge (S. Brown & Smith, 1996:1). The more diverse the learning resources, the more students can access them without being restricted by space or time. PBL is a flexible learning model that supports online learning, enabling students to choose from various ways and resources available to aid their mastery of the subject matter (Armatas et al., 2003). This allows the critical thinking skills of the students to develop, as they take responsibility for solving problems on their own. Previous studies revealed that Resource Based Learning can enhance student independence (Khusniawati, 2019). Based on the background description above, the researcher is interested in further investigating the effect of Problem-Based Learning Integrated with Information Technology on student independence in historical subjects.

2. RESEARCH METHODS

This study uses mixed methods, which contains quantitative and quantitative approaches (Creswell, 2014). Quantitative research is an approach that tests objective theory by examining the relationship between variables. Quantitative research in the field of education is a research method that focuses on collecting and analyzing numerical data to understand and explain educational phenomena. This approach aims to quantify variables, establish relationships, and make statistical inferences based on empirical evidence. Quantitative research involves the measurement of variables using standardized instruments or scales. It relies on numerical data that can be analyzed using statistical techniques. Examples of quantitative variables in education include test scores, attendance rates, or survey responses on Likert scales. Quantitative research aims to be objective and replicable. It strives to minimize bias and subjectivity by using standardized procedures and clear definitions. This allows other researchers to replicate the study and verify the findings. Quantitative research often utilizes large sample sizes to ensure statistical power and generalizability

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of findings. By collecting data from a representative sample, researchers can make inferences about the larger population of interest. Quantitative research employs various statistical analysis techniques to analyze the collected data. These techniques include descriptive statistics (e.g., mean, standard deviation), inferential statistics (e.g., t-tests, ANOVA), correlation analysis, regression analysis, and multivariate analysis. Quantitative research aims to establish causal relationships between variables through experimental or quasi-experimental designs. Researchers manipulate independent variables and measure their effects on dependent variables, controlling for confounding factors.

Qualitative research in the field of education is a research method aimed at understanding educational phenomena through a descriptive and interpretive approach. In this type of research, the main focus is on meaning, perspectives, and contexts involving individuals, groups, or educational institutions. Qualitative research seeks to describe and understand educational phenomena in depth. Researchers strive to gain a holistic understanding of the context, processes, and experiences involved in the researched educational situation. Qualitative research in the field of education can provide an in-depth understanding of various aspects of education, such as teacher-student interactions, student experiences in learning, decision-making processes by school staff, or the implementation of educational policies. Through this approach, qualitative research can provide insight Using an experimental research design. Experimental research is defined as research in which an independent variable is given treatment while other relevant variables are controlled, and their influence on one or more dependent variables is observed (Gay, Geoffrey E. MIlls, 2012). With a quasi-experimental design that includes a pretest-post-test non-equivalent group design.

The Type of Research, Approach, and Brief Research Procedure

This study uses design a Pre-test – Post-test Non-equivalent group design by using two groups/classes that are given different treatments. The design of pre-test – post-test Non-equivalent group design consist of two groups which were the experimental group and control group with different treatment (Sumardi et al., 2022). The experimental class is a class that is given treatment, i.e the implementation of PBL-STEAM equipped with Jbatik software (Yuliani, 2018). While the control class is a class treated by PBL-STEAM but it did not use the Jbatik Software in this research. Then, after the post-test is given, the student's creative thinking skills will be compared between the experimental class and the control class by Sugiono (2017). The quasi-experiment design of the non-equivalent control group is shown in Table 2 below.

Table 2. The quasi-experiment design of non-equivalent control group

Class	Pre-test	Treatment	Post-Test
Experimental Class	O_1	PBL-STEAM with Jbatik Software	O_2
Control Class	O_3	PBL-STEAM without Jbatik Software	O_4

Notes:
O_1: Pre-test score of experimental class before treatment
O_2: Post-test score of experimental class after treatment
O_3: Pre-test score of control class before treatment
O_4: Post-test score of control class after treatment

The STEAM approach is an integration between Science, Technology, Engineering, Arts, and Mathematics. The STEAM approach trains students to learn, find, plan, and solve problems (Sudarsono et al., 2022). The typology of STEAM learning is classified into four sections, namely content integration, pedagogical integration, and learner integration (Cheng & So, 2020). The STEAM problem in designing Batik motifs using Jbatik software is shown in Figure 2.

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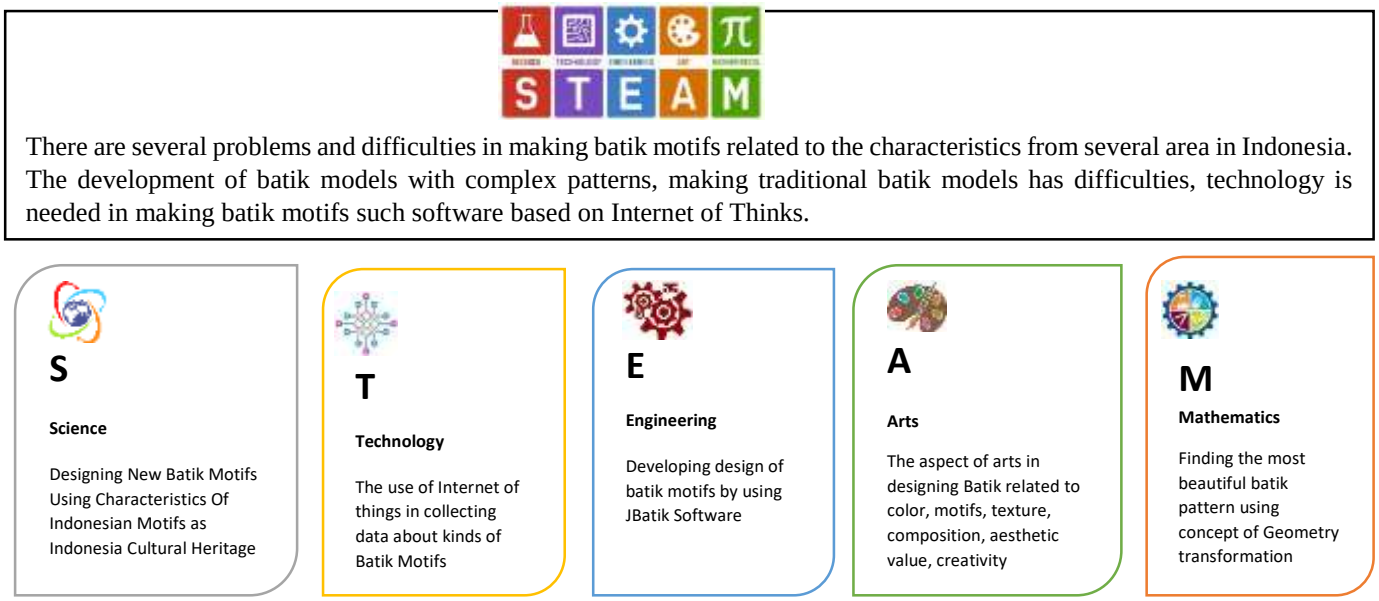

Figure 2. The STEAM problem in designing of Batik motifs using Jbatik software

Research subject/Participant

The population of this study is the 11th-grade students of SMA Negeri Rambipuji in the academic year 2022/2023. The sample used in this study is 60 students consisting of 29 Students in the experimental class and 31 students in the control class. The sampling technique used is not random sampling but using a homogeneity test to determine the similarity of the population variance. Then, for determining the experimental group and the control group, the average value of the student's daily grades in history subject is used.

Data Collection and Instrument

The instrument used to measure creative thinking skills consists of pre-test and post-test questions with a scale of 1-100. The questionnaire also used in this study consists of several written statements given to students to obtain information about their creative thinking skills in 11th-grade history class for social science students. The instrument for measuring student independence is in the form of a questionnaire with a rating scale model that requires respondents to answer statements with the choices of SD (Strongly Disagree), D (Disagree), A (Agree), and SA (Strongly Agree). The validity of the independence instrument was tested using the Product Moment correlation assisted by SPSS 22 for Windows software and its reliability using the Cronbach Alpha technique assisted by SPSS 22 for Windows.

Data Analysis Method

The data analysis method used statistical inferential analysis with SPSS software to determine whether there is an effect of the implementation of PBL-STEAM learning materials on students' historical literacy using the Independent Sample t-test. This t-test aims to determine the difference in creative thinking skills between the experimental class under PBL-STEAM implementation with JBatik Software and the control class under PBL-STEAM implementation without JBatik software. The independent sample t-test was analyzed by considering the Independent Sample t-test score. If the score has a sig value (2-tailed) less than 0.05 (p =<0.05), then there is a significant difference in the student's creative thinking skill between the experimental class and the control class (Rohim et al., 2019). On the other hand, if the score of sig (2-tailed) is greater than 0.05 (p = > 0.05), then there is no significant difference. Before the Independent Sample t-test was conducted, the normality test and the homogeneity of the data were first tested. A normality test is used to determine the condition of the data is normally distributed or not (Haydn et al., 2003). The normality test uses the Kolmogorov-Smirnov test. Data is categorized as normal if it has a significance score of more than 0.05 (> 0.05). While the homogeneity test is used to determine whether the two classes have homogeneous data or not. The homogeneity test criterion is

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if the significance value is more than 0.05 (> 0.05), then the variance of two group's data is the same (homogeneous), but if the significance value is less than 0.05, then the variance of two groups data is not the same (non-homogeneous). Furthermore, the research was continued by conducting in-depth interviews to triangulate the data analysis results using NVIVO software. The model of the triangulation method is shown in Figure 3 below.

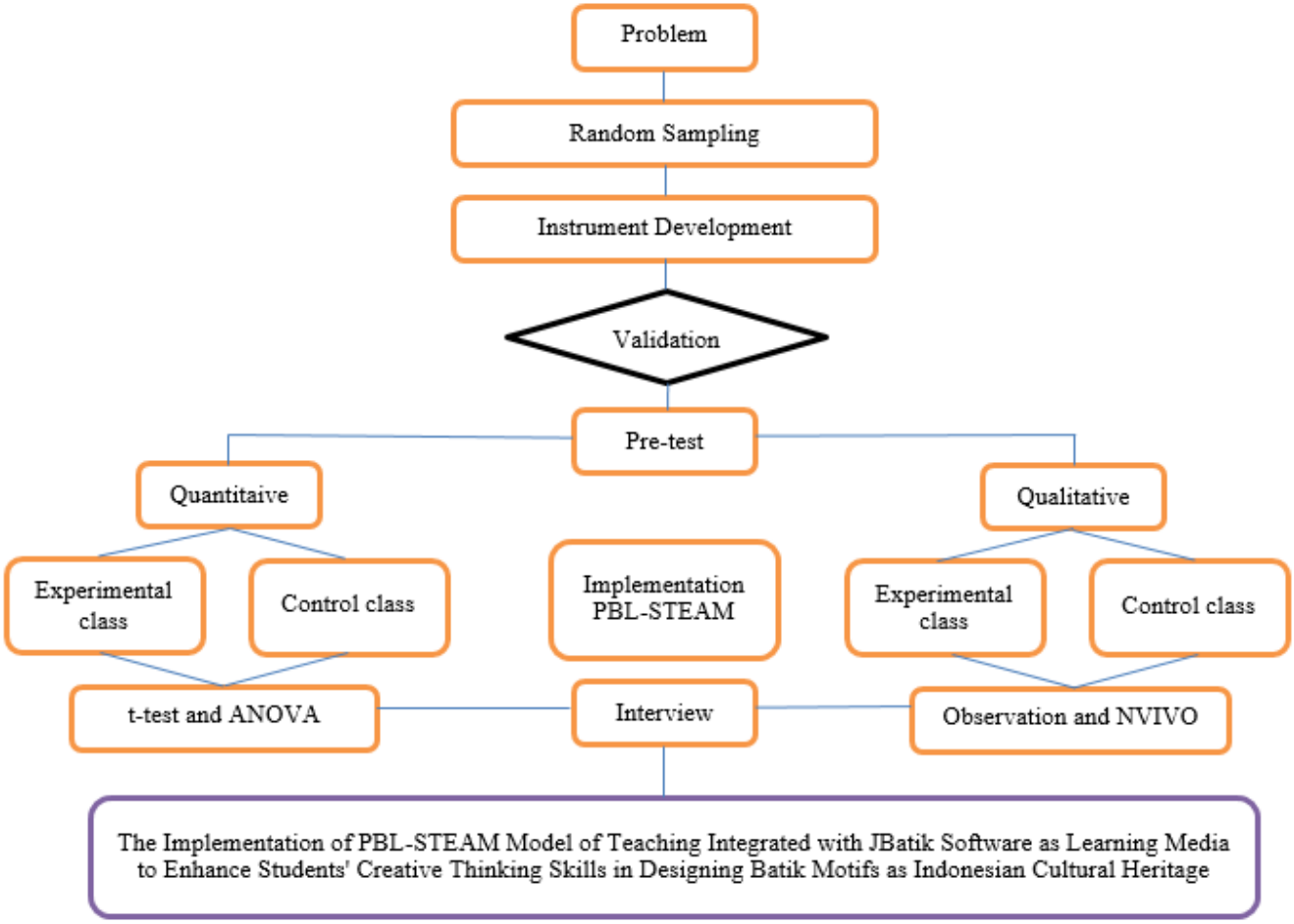

Figure 3. The model of triangulation method

Validity Test

Each item of the instrument's content validity testing is done using the correlation between the score of each instrument item and the total instrument score. The item is considered valid if $r_{score} > r_{table}$ or vice versa. An instrument can be considered valid if it has high validity and vice versa (Arikunto, 2013). If a question is found to be invalid, it will be discarded and not used, while valid questions will be used as research instruments. The validity of item questions will be tested using the Product Moment correlation formula with the help of SPSS 22 software for Windows in analyzing the correlation of item questions with the total score. The obtained correlation results are then compared with the r_{table} at the significance level of 0.05. The correlation results are considered valid if the correlation value of the item is equal to or greater than the r_{table}. However, if the correlation value of the item is smaller than the r_{table}, it is considered invalid.

Reliability Test

The purpose of conducting a reliability test is to determine whether the test items used are reliable or not. According to Ary, et al. (2010:201), reliability is the extent to which a test assesses accurately and consistently. To avoid complicating students and researchers, the test instrument must meet practical requirements. The instrument's reliability test in this study used the Spearman-

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Brown reliability test with the Split Half technique aided by SPSS 22 software for Windows. If the test items show high reliability, the instrument is considered reliable and can be used as a research instrument. The prerequisite test analysis consists of a normality test, homogeneity test, and hypothesis test. Before conducting the hypothesis test, normality and homogeneity tests need to be performed. If they meet the requirements, the testing is continued with the hypothesis test using one-way ANOVA, which is included in parametric data analysis.

Normality Test

The normality test determines whether the data is normally distributed or not. The normality test was conducted on the results of the independence questionnaire of the students from experimental groups 1 and 2 using the Kolmogorov-Smirnov formula with the assistance of SPSS 22 for Windows.

Homogeneity Test

The homogeneity test determines whether population variances are equal or not. In this study, the analysis used the test of homogeneity of variances with Levene's statistic through the SPSS 22 for Windows program. The homogeneity test was conducted to determine the experimental and control groups.

Hypothesis Testing

The hypothesis testing in this research is conducted using a one-way ANOVA test assisted by SPSS 22 for Windows. The purpose of conducting one-way ANOVA is to determine whether there is an influence on students' independence between the experimental class taught using the Problem-Based Learning Integrated with the Technology model and the control class taught using Resource-Based Learning. A one-way ANOVA test is conducted to test the differences in the mean between the two groups.

3. FINDINGS

3.1 INSTRUMENT TRIAL RESULT

A. Validity Test

The validation of the content of each instrument item is carried out using the correlation between the score of each instrument item and the total score of the instrument. An item is considered valid if $r_{score} > r_{tab}$ or vice versa. An instrument can be called valid if it has high validity, and vice versa (Arikunto, 2013). The validity of each item will be tested using the Product Moment correlation formula assisted by SPSS 22 for Windows software in analyzing the correlation of each item with the total score. The correlation results obtained are then compared to the r-table at the significance level of 0.05. Correlation results are considered valid if the correlation value of the item is equal to or greater than the r-table. However, if the correlation value of the item is less than the r-table, it is considered invalid.

The data obtained from the validity test of the instrument, which is a questionnaire before and after treatment, consists of 18 statements arranged based on indicators of independence according to (Steinberg, 2017) developed by (Wulandari, 2019). The validity test results showed that the test items on the independence variable have an r-value greater than the r-table (r-value> r-table), and the overall significance value is less than the 5% level of significance (0.05). This indicates that all items in the questionnaire are valid and can be further analyzed.

B. Reliability Test

The purpose of conducting a reliability test is to determine whether the test items used are reliable or not. This research uses the Cronbach Alpha reliability test technique using SPSS version 22 for Windows, using the reliability coefficient criteria according to Guilford (1956), which include:

a. $0{,}80 < r_{11} \leq 1{,}00$ indicates very high reliability;
b. $0{,}60 < r_{11} \leq 0{,}80$ indicates high reliability;
c. $0{,}40 < r_{11} \leq 0{,}60$ indicates moderate reliability;
d. $0{,}20 < r_{11} \leq 0{,}40$ indicates low reliability;
e. $-1{,}00 < r_{11} \leq 0{,}20$ indicates low reliability.

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Table 3. Reliability test

Variabel	N	Spearman-Brown Coefficient	Information
Creative thinking Skills	30	0,911	very high reliability

Based on table 3 above shows that the independence questionnaire instrument has a value of 0.911 which falls into the category of $0.80 < 0.911 \leq 1.00$ (very high reliability). Thus, it can be concluded that both instruments are reliable and show good consistency.

3.2 ANALYSIS PREREQUISITE TEST

A. Normality Test

The purpose of conducting a normality test is to see whether the data is normally distributed or not. The normality test is performed using the values of the independence questionnaire before and after the treatment in the experimental and control groups. The test is carried out using the Kolmogorov-Smirnov formula with the help of SPSS version 22 for Windows.

Table 4. Normality test in experimental class

Data	N	Sig.	Information
Pre-test	30	0,200*	Normal distribution
Post-test	30	0,180*	Normal distribution

Table 5. Normality test in control class

Data	N	Sig.	Information
Pre-test	30	0,200*	Normal distribution
Post-test	30	0,121*	Normal distribution

Based on the normality test results in Tables 4 and 5 above, in the experimental group, the significance value before treatment was 0.200 (0.200 > 0.05), and after treatment, it obtained a significance value of 0.180 (0.180 > 0.05). Meanwhile, the control group showed a significance value of before treatment of 0.200 (0.200 > 0.05) and after treatment obtained a significance value of 0.121 (0.121 > 0.05). Thus, it can be concluded that the data in the experimental and control groups are normally distributed.

B. Homogeneity Test

A homogeneity test is conducted to determine whether data comes from the same population variance or not. The homogeneity test is performed using the analysis of the test of homogeneity of variances with the Levine test statistic.

The homogeneity test in this study was assisted by SPSS 22 for Windows. The criteria for determining the results of the homogeneity test are as follows: (a) The data can be called homogenous if it shows a significance value > 0.05; (b) The data can be called heterogeneous if it shows a significance value < 0.05.

Table 6. Homogeneity Test

Variable	*Lavene Statistic*	N	Sig.
Regular Examination	1,057	90	0,528

Based on the homogeneity test results from Table 6 above, the significance value is 0.528 (0.528 > 0.05). Thus, it can be interpreted that the XI IPS class has a homogeneous range of values. This means that the variance homogeneity requirement is fulfilled. Next, the sample selection is carried out using the average values between classes.

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IJCSRR @ 2023
www.ijcsrr.org

Table 7. The average regular examination

Class	Average
XI IPS 1	84,83
XI IPS 2	83,50
XI IPS 3	84,17

Based on the Table 7 above, the XI IPS 1 class is chosen as the experimental group that will be taught using Problem-Based Learning Integrated with the Information Technology model, while the XI IPS 3 class is chosen as the control group that will be taught using the Resource Based Learning model.

C. Hypothesis Testing

Hypothesis testing in this study uses a one-way ANOVA test assisted by SPSS 22 for Windows. The purpose of conducting a one-way ANOVA test is to determine whether there is an effect of student independence between the experimental class taught using Problem-Based Learning Integrated with the Information Technology model and the control class taught using the Resource-Based Learning model. The one-way ANOVA test is capable of testing the difference in means between two groups. The data used for hypothesis testing are normally distributed and have the same homogeneity. The decision criteria for the one-way ANOVA test include the following: if the significance value (sig.) is more than 0.05, then H0 is accepted. Conversely, if the significance value is less than 0.05, then H0 is rejected. Furthermore, the Least Significant Difference (LSD) posthoc test is used to determine whether there are differences in means or significance between the two groups (control and experimental).

Table 8. One Way Anova test

	Sum of Squares	df	Mean square	F	Sig.
Between group	1806.000	3	602.000	35.680	0.000
Within Group	1957.200	116	16.872	0.000	0.000
Total	3763.200	119	0.000	0.000	0.000

Based on Table 8 of ANOVA test results above, the obtained F-value is 35.680, and the significance value is 0.000 (0.000 < 0.05). At df=116, at the significance level of 5% (0.05), the F-table value is 3.07. The obtained F-value in the Table above is 35.680, F-value > F-table (35.680 > 3.07) with a significance of 0.000 < 0.05, so H_0 is rejected and Ha is accepted. It can be concluded that there is an effect of the Problem-Based Learning Integrated with Information Technology model on the students' independence. Next, a posthoc test using LSD (Least Significant Difference) was conducted to determine whether there were any significant differences in the means or significance between the two groups (control and experimental).

Table 9. LSD Test

Class 1 (I)	Class 2 (J)	Mean Difference	Std. error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Experiment Class (before treatment)	Experiment Class (after treatment)	-9.6	1.061	0.000	-11.7	-7.5
	Control Class (before treatment)	-1.133	1.061	0.287	-3.23	0.97
		-6.2	1.061	0.000	-8.3	-4.10

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IJCSRR @ 2023
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	Control Class (after treatment)					
Experiment Class (after treatment)	Experiment Class (before treatment)	9.6	1.061	0.000	7.5	11.7
	Control Class (before treatment)	8.467	1.061	0.000	6.37	10.57
	Control Class (after treatment)	3.4	1.061	0.002	1.3	5.5
Control Class (before treatment)	Experiment Class (before treatment)	1.133	1.061	0.287	-0.97	3.23
	Experiment Class (after treatment)	-8.467	1.061	0.000	-10.57	-6.37
	Control Class (after treatment)	-5.067	1.061	0.000	-7.17	-2.97
Control Class (after treatment)	Experiment Class (before treatment)	6.2	1.061	0.000	4.1	8.3
	Experiment Class (after treatment)	-3.4	1.061	0.002	-5.5	-1.3
	Control Class (before treatment)	5.067	1.061	0.000	2.97	7.17

Based on Table 9 above, the LSD posthoc test results in the Table, there is a difference in independence data after treatment in the experimental group in Table I compared to before treatment in the experimental group in Table J with a significance of 0.000, which is smaller than 0.05, and a mean difference (I-J) of 9.600. Meanwhile, there is also a difference in questionnaire data after treatment in the control group in Table I compared to before treatment in the control group in Table J with a significance of 0.000, which is smaller than 0.05, and a mean difference (I-J) of 5.067. Based on the results of both groups, it can be concluded that the experimental group taught using the Problem-Based Learning Integrated with the Information Technology model has a better influence on independence compared to the control group taught using the Resource-Based Learning model.

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IJCSRR @ 2023
www.ijcsrr.org

The following analysis is for qualitative research using NVIVO software to analyze the results of interviews conducted with three students with different levels of creative thinking skills. There are three students selected, namely S1 with a high level of creative thinking skills, S2 with a moderate level of creative thinking skills, and S3 with a low level of creative thinking skills. NVIVO software has many features that can be used. The first feature is Word Frequency Query which is used to visualize the text. The results of this feature can be seen in Figure 4. Figure 4 shows that the most frequently appearing word in the interview text is "Batik" with a frequency of 4.34%. This is followed by the words "ideas," "motifs," and "design."

Figure 4. Word Cloud from NVIVO

The next feature is the Text Search Query. This feature is applied to understand the meaning of words in the word cloud in Figure 4. In this study, the researcher selected the word "STEAM" as one of the keywords in this research. The following search results are presented as a word tree in Figure 5. Based on Figure 3, information is obtained stating that after the students understand the concepts of STEAM and problem-based learning, they feel it easier to solve problems and design creative batik motifs; they believe that this learning method is very effective because it allows them to learn while working on challenging projects and developing their STEAM skills; many students combine different STEAM concepts in designing batik; students use STEAM and problem-based learning; they had the opportunity to use the STEAM approach; etc.

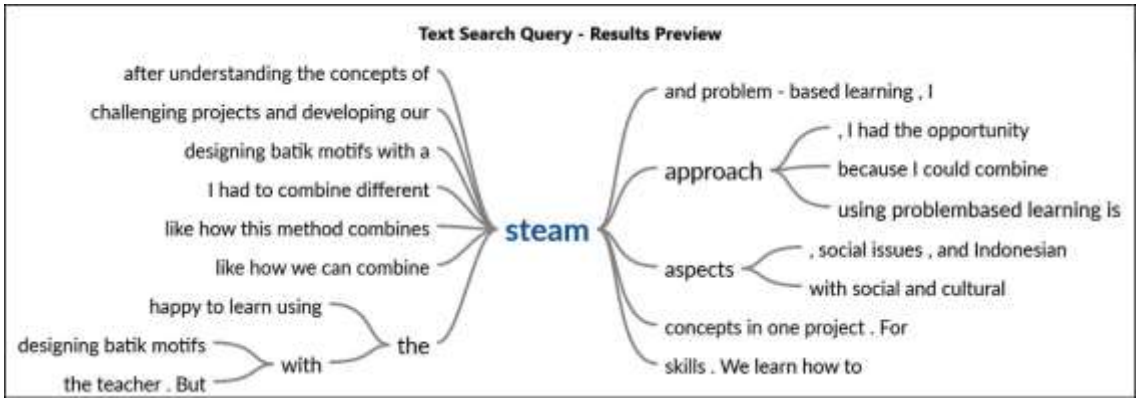

Figure 5. Word Tree of the Usage of the Word "STEAM"

Next, we will analyze the comparison between two interviewees using the Compare File feature. The results of this feature can be seen in Figure 6. Figure 6(a) compares the creative thinking skills level between S1 and S2. Based on Figure 6(a), it is found that there are thinking indicators possessed by S1 and S2, namely Fluency, Flexibility, Originality, Elaboration, Problem Sensitivity, and Risk Taking. S1 only possesses the indicators of Originality of Expression and Curiosity. Then, there is Figure 6(b), which compares the creative thinking skills level between S1 and S3. Based on Figure 6(b), it is found that there are thinking indicators possessed by S1 and S3, namely Fluency, Flexibility, Originality, and Elaboration. The indicators of Problem Sensitivity, Risk Taking, Originality of Expression, and Curiosity are only possessed by S1. Finally, Figure 6(c) shows the comparison of the creative

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IJCSRR @ 2023
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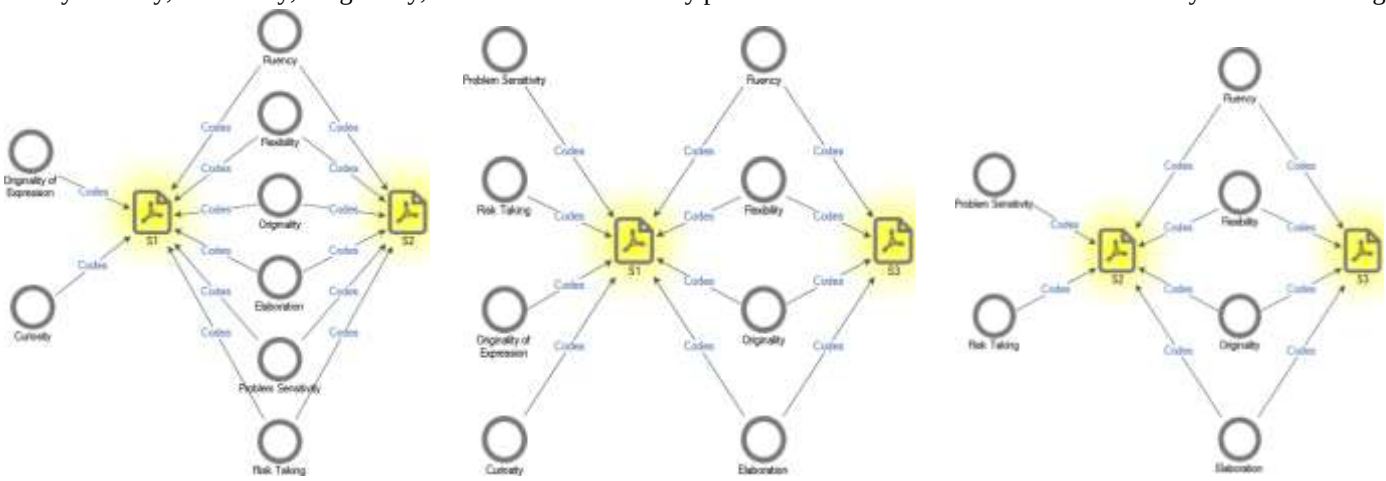
thinking skills level between S2 and S3. Based on Figure 6(c), it is found that there are thinking indicators possessed by S2 and S3, namely Fluency, Flexibility, Originality, and Elaboration. S2 only possesses the indicators of Problem Sensitivity and Risk Taking.



(a) (b) (c)

Figure 6. Results of Comparison of Levels of Creative Thinking Skills S1, S2, and S3

Another feature that can be utilized in NVIVO is the Project Map feature to see an overall comparison of each student and the coding achieved and to show the classification of the level of creative thinking skills of the students. The results of the Project Map feature can be seen in Figure 7. Based on Figure 7, we can see the comparison of which each student possesses indicators.

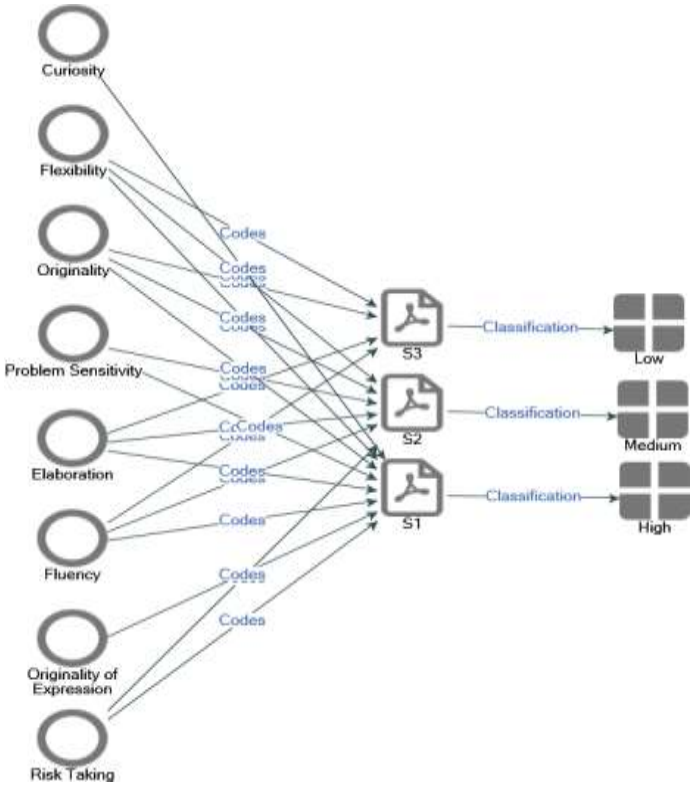


Figure 7. Project Map

The final analysis we conducted was comparing the similarity of the interview texts of the three students. The NVIVO feature used was "Item Clustered by Word Similarity," which can be seen in Figure 6, and the Pearson Correlation Coefficient values can be

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IJCSRR @ 2023
www.ijcsrr.org

seen in Table 10. Based on Figure 8, it can be seen that there is no blue line connecting S1, S2, and S3. This indicates no significant similarity between the interviews of S1, S2, and S3.

Table 10. Pearson Correlation Coefficient

Student A	Student B	Pearson Correlation Coefficient
S1	S2	0.529257
S2	S3	0.4572
S1	S3	0.433245

Based on Table 10 above, the Pearson Correlation Coefficient values of two students were obtained. S1 and S3 have a Pearson Correlation Coefficient value of 0.529257, S2 and S3 have a Pearson Correlation Coefficient value of 0.4572, and S1 and S3 have a Pearson Correlation Coefficient value of 0.433245. All the Pearson Correlation Coefficient values are less than 0.7. Based on this, there is no significant similarity between the interviews of S1, S2, and S3.

The next steps are quantitative statistical analysis by using an Independent Sample *t*-test to test whether there is a significant difference between the experiment class and control class under the implementation of the JBatik of the PBL-STEAM approach. Table 6 shows the result on the level of confidence 5% of the value of sig. (2-tailed) = 0,002<0.05. It means $t_{score} > t_{table,}$ which concludes H_1 is accepted and H_0 is rejected. It implies the difference between the two classes is significant. It concludes that the PBL-STEM model of teaching integrated with JBatik software improves students' creativity in designing the Indonesian batik motifs as Indonesian cultural heritage. The result of the Independent sample t-test analysis is shown in Table 6 below.

Table 6. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	0.083	0.663	-2.703	49	.002	-2.523	0.687	-2.512	-0.721
	Equal variances not assumed			-3.004	35.124	0.002	-2.353	0.585	-2.346	-0.523

Table 7. The descriptive data of the student's historical literacy trough their tests

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test of Experiment Class	29	54	70	72.14	1.212
Post-test of Experiment Class	29	75	91	81.25	1.325
Pre-test of	31	56	72	65.70	0.927

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www.ijcsrr.org

Control Class					
Post-test of Control Class	31	64	77	73.20	0.845

Based on table 7 above, we can conclude that the implementation of PBL-STEAM learning materials can improve students' creative thinking in designing the Indonesian batik motifs as Indonesian cultural heritage (Nurainun et al. 2008). The achievement of the student's creative thinking in the experimental class is higher than the scores of the students' students' creative thinking in the control class.

4. DISCUSSION

This study aims to examine the effect of Problem-Based Learning Integrated with the Technology model on student autonomy in the history subject. The study consisted of two groups, namely the experimental group taught with Problem-Based Learning Integrated with the Technology model and the control group taught with the Resource Based Learning model. The hypothesis testing in this study used a one-way ANOVA test aided by SPSS 22 for Windows. The hypothesis testing results obtained an F value of 35.680 and a significance of 0.000 (0.000 < 0.05). At df=116, the significance level at 5% (0.05) is 3.07. The F value in the Table above is 35.680, F value > F table (35.680 > 3.07) with the significance of 0.000 < 0.05, so H_0 is rejected, and Ha is accepted. It can be concluded that there is a significant effect on the autonomy of students taught with the Problem-Based Learning Integrated with the Technology model in experimental class 1. This study aimed to examine the effect of a model.

The score of the mean difference in independence between the experimental group taught using Problem-Based Learning Integrated with Technology and the control group taught using Resource-Based Learning can be examined through the LSD (Least Significant Different) test results. The LSD test results for the experimental group in Table I with data before treatment in Table J showed a difference with a significance of 0.000 less than 0.05 and a mean difference (I-J) of 9.600. Meanwhile, the questionnaire data after treatment in the control group in Table I with data before treatment in Table J showed a difference with a significance of 0.000 less than 0.05 and a mean difference (I-J) of 5.067. Based on the results of both groups, it can be concluded that the experimental group taught using Problem-Based Learning Integrated with Technology has a better influence on independence compared to the control group taught using Resource Based Learning.

According to previous research, this study provides an overview that the Problem-Based Learning Integrated with Technology model helps students in the learning process, makes learning more active and engaging, provides a pleasant atmosphere, encourages critical thinking skills leading to an increase in problem-solving abilities, and improves students' independence in the learning process and creative thinking skills in designing Batik motifs. In designing batik, creative thinking is highly important as it provides room for innovation and self-expression. Creative thinking allows batik designers to create unique and distinct patterns and designs that haven't been seen before. By combining traditional elements with new ideas, batik can become an intriguing and fresh form of art. Creatively designed batik has a greater appeal to consumers. Innovative and captivating designs can attract the attention of a wider audience, both those familiar with batik and those who have never seen it before. This can help expand the batik market and develop the batik industry as a whole. Batik is a rich cultural heritage with high historical value. In designing batik, creative thinking enables designers to express their cultural identity in new and interesting ways. By blending traditional elements with modern styles, batik can serve as a means to strengthen and renew our cultural heritage. Creative thinking also allows batik designers to explore new and unconventional techniques and materials. By combining traditional dyeing techniques with modern technology or using non-traditional materials, batik can have a different appearance and texture. This opens up opportunities for exploration and new discoveries in batik making. In the era of globalization, creative thinking in batik design can help enrich the overall creative industry.

Graphic design software can be used for reverse engineering existing batik patterns. For example, if there is a traditional batik motif that needs modification or adaptation, designers can import the motif into the software and modify it as required. This allows designers to modernize or diversify existing batik patterns. In designing batik patterns, considering the size and scale of the motif is important. Design software enables designers to view the motif in different sizes and easily adjust it as needed. Designers can also see in real-time how the pattern will look on different fabrics. Color is a crucial element in batik pattern design. With design software, designers can test various color palettes on the pattern, mix and match colors quickly, and see the results in real-time. This helps in choosing optimal color combinations and visualizing how the pattern will appear when applied to the fabric. Once the batik

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IJCSRR @ 2023
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pattern is designed, design software allows designers to create comprehensive documentation. They can generate technical specifications, construction diagrams for the pattern, and clear usage instructions. The software also facilitates delivering the design in various file formats that can be used by stakeholders such as batik craftsmen or textile manufacturers. It is important to note that while graphic design software greatly aids the process of designing batik patterns, strong design skills and knowledge are still necessary. The software is merely a tool that enhances the efficiency and flexibility of designers.

The results of this study support Brodie's (2006) research that shows the use of Problem-Based Learning integrated with technology can improve problem-solving skills, teamwork, self-directed learning, and communication skills. This indicates that PBL integrated with technology provides ease in the learning process, such as easy access to information and discussion. The use of technology in Problem-Based Learning is to support students through the problem-solving process by providing tools and resources (Albion, 2007:3). The role of technology in Problem-Based Learning can make it easier to search for information sources (Aryanti et al., 2017:15-18). The application of technology in the learning process is one-way educators improve learning outcomes. Therefore, the level of independence of students taught using the Problem-Based Learning Integrated with Technology model is better than those taught using the Resource-Based Learning model. This is because experimental class 1 is a model of learning that is integrated with information technology.

The results of this study also support previous research conducted by Sabil et al. (2021) titled "Problem-Based Learning Model in Classroom Management with Scaffolding Techniques on Learning Outcomes and Student Independence," which states that independence plays an important role in students' activity in learning and motivates them to develop problem-solving skills, self-efficacy, and creative thinking. The results of their study revealed a significant difference in the application of the Problem-Based Learning model with scaffolding techniques on the independence and learning outcomes of students.

The Problem-Based Learning model integrated with technology makes learning more flexible and less boring for students (Pujirahayu et al., 2020:219). An effective way to implement Problem-Based Learning is by integrating it with technology. Technology is an important tool in the process of searching for information, decision-making, and presenting solutions during PBL activities. Integrating technology with PBL provides meaningful learning experiences for educators and students alike (Park et al., 2004:703). The Problem-Based Learning model integrated with technology emphasizes learning through problem-solving. This way, students are trained to think critically to solve problems. The use of technology in the implementation of the PBL model benefits students by facilitating information retrieval, thereby training them to take responsibility for their learning and making learning more optimal.

5. CONCLUSIONS

This study concludes that there is an influence of the Problem-Based Learning Model Integrated with Information Technology on the independence of students in the subject of history. The One-way ANOVA test results on the independence variable showed a significant influence. Through the LSD test, it was shown that there were differences in the mean difference between the experimental group and the control group. It can be concluded that the experimental group taught using the Problem-Based Learning Model equipped with JBatik software has a significant impact on creative thinking skills compared to the control group taught using the Problem-Based Learning Model. The Arts aspect from students also increases because according to color composition from JBatik Software. This is because Problem-Based Learning Integrated with Technology helps students in the learning process of designing batik and enriching the Batik motifs, makes learning more active and not boring, provides a pleasant atmosphere, encourages students to think critically so that problem-solving skills increase in the development Batik Motifs, and increases the independence of students in the learning process (Sumardi et al., 2023). This study recommends that educators are expected to apply the Problem-Based Learning Model Integrated with Information Technology in the Batik design as part of the history learning process so that students become more active and responsible, have a broad perspective, and can use technology properly.

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IJCSRR @ 2023
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