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DEVELOPMENT OF 21st CENTURY SKILLS THROUGH STEAM PJBL IN THE TOPIC OF SALT HYDROLYSIS AND BUFFER SOLUTIONS

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ABSTRACT

Globalization influences various aspects, including education, so learning is needed to improve skills and quality of life abilities. This research aims to develop 21st-century skills through project-based learning (PjBL) and STEAM (Science, Engineering, Technology, Art, and mathematics). Participants in this study were 40 students in eleventh grade in the science program. This study used qualitative methods, which focused on the integration and implications of PjBL with the STEAM model on salt hydrolysis and buffer solutions. The STEAM project is a mockup of electrical conductivity and water purification on salt hydrolysis and hydroponic plant cultivation for projects on buffer solution—data collection techniques through interviews, reflective journals, classroom observations, and teacher diaries. The results showed that students were interested and motivated in making STEAM projects. 21st Century skills consisting of life and career skills can be seen from the initiative and a sense of responsibility in doing projects, learning and innovating skills seen from student creativity and innovation, and technology skills seen through marketing project creative ideas through information media and technology. Other implications, such as curiosity, motivation, and confidence, arise in the learning process. Based on its integration and implications, the STEAM approach with PjBL can be used as an alternative to improve 21st-century skills in chemistry learning

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INTRODUCTION

Civilization changes impact changes in aspects of life, not only in science and technology but also in the economic, social, and political fields. Therefore, skills such as learning and innovation, life and career skills, skills to use technology, media and information, and communication skills are needed to guarantee life to survive and be independent in facing global competition, known as 21st-century skills [1].

The Indonesian education system, which uses the 2013 curriculum, encourages the learning process of knowledge, attitudes, and skills [1,2]. Learning that is oriented towards developing soft skills helps students not only in developing insights and knowledge about the science being studied but also in developing other skills and expertise, such as developing reasoning power, curiosity, critical and creative thinking, and being able to collaborate [2] so that soft

skills need to be put forward [3]. One of them is through STEAM, critical thinking skills, reasoning power, and curiosity, which can be done through scientific exploration [7].

The skills required in the 21st century exhibit similarities with the soft skills emphasized in the 2013 curriculum, as these soft skills are essentially rooted in the 21st-century skill set for students. An emerging educational approach in the United States known as STEM (Science, Technology, Engineering, and Mathematics) aims to cultivate skills and promote the integration of diverse fields of learning. Chonkaew exemplifies the application of STEM-based learning to the stoichiometric topic, where efforts to enhance analytical skills and foster a positive disposition toward science have been made. Through the implementation of STEM in conjunction with Problem-Based Learning (PBL), students are encouraged to cultivate their analytical thinking abilities. This pedagogical approach compels students to engage in problem exploration, formulation, and innovation as they work toward resolving complex issues [27].

STEM applies multidisciplinary learning of science, technology, engineering, and mathematics packaged in a lesson. However, with the development and economic needs, it turns out that the elements of art need to enter into STEM so that STEM turns into STEAM [4]. STEAM emerged so art teachers could apply the STEAM approach in the classroom so that interdisciplinarity in the arts and sciences could lead to curricular components that combine aesthetic and analytical modes. Converting STEM to STEAM makes learning more meaningful with problem-solving, courage, critical thinking, and skills.

The implementation of STEAM-based education contributes to the development of individuals capable of critical, logical, and systematic reasoning, enabling them to effectively address global challenges and contribute to the advancement of the national economy [1,4]. The future prosperity of Indonesia hinges significantly on cultivating higher-order thinking skills, particularly within the realm of STEAM education [1,4]. By adopting an integrated approach to STEAM education, the quality of Indonesia's human resources can be enhanced, instilling them with interdisciplinary knowledge that prepares them for the demands of professional roles in alignment with the ASEAN Economic Community (AEC). Concurrently, this approach aligns with Indonesia's aspiration to position itself as the world's seventh-largest economy by 2030.

The results of observations of chemistry learning for one semester (even semester) at a high school in Tangerang showed that when students are given chemistry content with the Think Pair Square learning method using story dilemmas, students are actively involved and enthusiastically involved in the learning. This shows that the learning process has gone well. Still, based on the results of interviews with several students, students who need learning can develop creative ideas and manifest in learning such as poetry, songs, and poetry musicalization. Therefore, there is a need for another approach to accommodate students' innovative ideas in learning chemistry.

Learning with the STEAM approach is one of the innovations that can be applied in chemistry learning to develop students' skills and creativity. One of them is the topic of chemical bonds. The use of molymod is from 3-dimensional art, so studying this abstract, the case of chemical bonds is more accessible for students to understand because it is visualized in a more real form. Learning abstract chemistry is more fun and more accessible for students to understand [5].

The STEAM approach can be done using the project-based learning model, where there will be collaborative interactions in work groups so that students can create a project that develops their soft skills [6,22]. The use of PjBL makes STEAM applicable because the project is done, and it shows the soft skills of the students [21,23].

Utilizing qualitative research methods, the STEAM approach employs various data collection methods, including STEAM observation sheets monitored by observers, observational notes, reflective journals from both students and researchers, interviews, and complemented by instruments evaluating 21st-century skills. The adoption of the STEAM approach in research can play a significant role in expanding students' knowledge horizons [7]. Furthermore, its efficacy extends to Chemistry and Biology education, as evidenced by the successful implementation of projects like the rain project [8]. The STEAM approach has also demonstrated its effectiveness even within art schools, where it effectively enhances student motivation [9].

Based on its characteristics, the topic of salt hydrolysis and buffer solutions is factual, conceptual, and procedural [24]. Students are expected not only to understand the chemical concept but also issues related to chemistry and problems related to the content and play an active role in solving problems related to the concept. So, chemistry learning must be a means of developing students' abilities in social life and solving problems.

To understand this topic, students must understand the concept well. Therefore, the STEAM approach reduces teacher-centered learning and textbooks and increases student activity and creativity in this topic [26]. This research analyzes the implications and integration of the application of the STEAM (Science, Technology, Engineering, Art, and Mathematics) approach with the Project Learning method on the topic of Salt Hydrolysis and Buffer Solutions to Develop 21st Century Skills as an alternative chemistry learning that can be done to develop students' soft skills.

METHODS

This study employs a qualitative research methodology [10], chosen for its ability to explore and contextually interpret data deeply. It aligns with the research's focus on comprehending students' perspectives on the integration and outcomes of the STEAM approach with PjBL. The qualitative nature of this research allows for an in-depth exploration of data and a contextual interpretation of the findings. Several methods were utilized to gather and analyze qualitative data.

Firstly, semi-structured interviews were conducted with students, providing a

platform to explore their experiences, opinions, and perceptions regarding integrating the STEAM approach. These interviews offer profound insights into the impact of the STEAM approach on student learning and skill development. Secondly, reflective journals were employed by both students and teachers to chronicle their thoughts, observations, and encounters throughout the implementation of the STEAM-PjBL approach. Student journals capture reflections and emotional responses concerning chemistry learning through the STEAM-PjBL method, while teacher journals provide valuable insights into the occurrences during the application of this approach. Thirdly, classroom observations were carried out during the STEAM-PjBL approach's execution to observe the dynamic involvement, collaboration, and interactions among students within the learning process. Lastly, a 21st-century skills questionnaire focused on life and career skills, learning and innovation skills, and technology and information media skills. This questionnaire gauged the STEAM approach's implications and influence in cultivating these vital skills.

Qualitative data collection involves diverse methods and subsequent processing, encompassing typing, recording, and editing. Qualitative data analysis retained its reliance on words, amalgamated into comprehensive narratives to extract meaning [10,25].

1. Data Analysis

The data for this research was gathered through various methods, including interviews, reflective journals from both students and teachers, classroom observations, and questionnaires assessing 21st-century skills. These data were subjected to qualitative analysis techniques. To ensure the quality of the study, trustworthiness was upheld by adhering to credibility criteria, which involved extended involvement, gradual subjectivity, and member validation [11].

2. Participants and Time of Study

This research was carried out with a focus on students in the eleventh grade, encompassing 40 participants during the even semester of the academic year 2016/2017. The study targeted this specific group of students to delve into the intricacies of the research topic, aiming to gain comprehensive insights into their experiences and perceptions. By selecting eleventh-grade students, the researchers aimed to capture diverse perspectives, opinions, and attitudes toward the subject matter, ensuring a representative sample. The choice of the even semester in the academic year 2016/2017 was deliberate, as it allowed the researchers to work with a well-established group of students who had already been exposed to certain educational experiences and curricular content. This temporal aspect was important to explore potential impacts or changes from these experiences. Furthermore, conducting the research in a school setting provided a controlled environment, enabling the researchers to gather data that accurately reflected the specific context of the student's learning journey. By meticulously selecting eleventh-grade students and conducting the

study during the specified academic semester, the research aimed to comprehensively investigate the intricacies of the subject matter while considering contextual nuances that could influence the findings and conclusions.

3. Stages of PjBL (Project-Based Learning)

This research applies Project Based Learning using the STEAM approach. The specific steps of PJjBL used in this study are outlined in Figure 1 [17]:

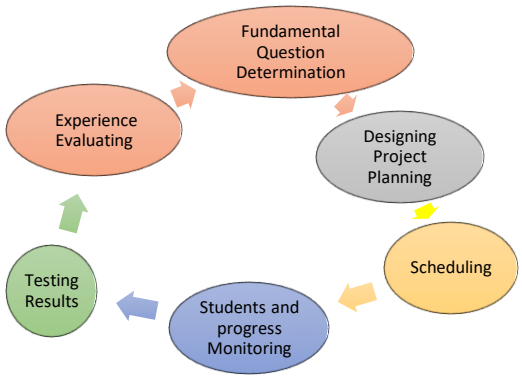

Figure 1. PjBL steps

4. Project STEAM Development

This study employed a multifaceted approach to gather the necessary data. The data collection process encompassed several distinct methods, each designed to provide a comprehensive and well-rounded understanding of the research topic. Interviews were conducted to engage directly with participants and explore their perspectives, opinions, and experiences related to the subject under investigation. Reflective journals, maintained by both students and teachers, served as valuable repositories of insights, capturing personal reflections and observations throughout the research period. These journals provided a unique window into the participants' thoughts and reactions as they engaged with the research context.

Additionally, classroom observations were carried out, enabling the researchers to witness the learning environment firsthand. This method facilitated the documentation of actual behaviors, interactions, and dynamics within the classroom setting, offering valuable contextual information to complement other data sources. Moreover, questionnaires were utilized to assess the participants' 21st-century skills, providing a structured approach to measuring specific competencies relevant to the research focus.

The collected data underwent qualitative analysis techniques to derive meaningful interpretations and insights. Qualitative analysis involves examining, coding, categorizing, and synthesizing the data to identify recurring patterns, themes, and underlying meanings. This analytical approach aimed to uncover deeper insights beyond surface-level observations, contributing to a richer understanding of the research phenomenon.

To ensure the rigor and credibility of the study, the research adhered to the trustworthiness principle. This involved upholding credibility criteria to enhance the validity and reliability of the findings. Extended involvement in the research context was maintained, allowing the researchers to develop a nuanced understanding of the participants and their experiences over an extended period. Gradual subjectivity was acknowledged, indicating that the researchers' perspectives

and biases could influence the interpretation of data. Member validation, a process where participants review and confirm the accuracy of their portrayed experiences, was employed to enhance the authenticity of the findings and ensure alignment with participants' perspectives. By employing this rigorous and comprehensive data collection and analysis approach, the research aimed to provide a robust and well-substantiated exploration of the research topic while adhering to established quality standards

RESULTS AND DISCUSSION

The results of the research and discussion are divided into two main parts, with the stages of the STEAM learning process using the PjBL model and their implications for 21st-century skills in learning chemistry.

1. STEAM Integration in Project-Based Learning (PjBL)

The amalgamation of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into character-infused chemistry education, coupled with the Problem-based Learning (PjBL) approach, seeks to cultivate 21st-century proficiencies. These skills were derived from a multifaceted dataset encompassing student interviews, reflective entries in student and teacher journals, external assessors' observations, 21st-century skill assessment tools implementation, and student-generated projects and posters [1,4,22,23]. Through the systematic analysis of this diverse dataset, the researcher systematically encoded and scrutinized the ramifications of incorporating the STEAM methodology within chemistry education. A collection of student reactions to the integration of STEAM-PjBL includes:

"*What I got from learning STEAM is I feel more creative to make things and can express my creativity through media, but if I put it out verbally, I can't do it."*
(Reflective Student Journal 7, March 8, 2017)
"I like learning using STEAM because the learning brings together several elements."
Reflective Student Journal 12, March 8, 2017)
"Learning with the STEAM approach is fun because we can use several learning ways. This STEAM can also be useful not only in chemistry lessons but other lessons as well."
Reflective Student Journal 16, March 8, 2017)

Based on reflective student journals, the application of STEAM-PjBL accommodates students who do not like to interact through words but through creativity in project assignments. Students know that the application of STEAM-PjBL can be used in other lessons. In addition, based on students' analysis, they learned that this STEAM consists of several elements.A detailed explanation of the STEAM integration of each element or aspect of learning can be described as follows:

a. S for Science

Aspects of science in project-based learning (PjBL), both on the topic of salt hydrolysis and buffer solutions related to students' ability in groups, can explain the benefits or functions of chemical concepts used in the project.

For the Water Purification project, students are expected to be able to explain the function of alum in water purifiers. The scientific element of making mockups of electrical conductivity was found when students explained comprehensively the hydrolysis reaction of salts. In hydroponics,

the aspect of science is seen in the student's explanation of the benefits of the buffer solution used.

b. T for Technology

Technology aspects in project-based learning (PjBL) related to students' group ability can explain the benefits or technology used in the project.

For the Water Purification project, students can explain the benefits of the internet to determine the arrangement of water purifiers that are good and effective in purifying water. The technological element in making electrical and hydroponic conductivity mockups is reflected when students explain the idea of making mockups and hydroponics obtained from the inspiration of ideas from mass media and the internet.

c. E for Engineering

The engineering aspects of the project can be seen from the students' proficiency in assembling tools used as projects in groups, both in making mockups of electrical conductivity, water purifiers, and hydroponic cultivation.

d. A for Art

The art aspect of the solution electrical conductivity mockup project is presented when students display the project results with various beautiful colors, sizes, and shapes. For the water purification project, there is no prominent art element; the majority of the conditions and arrangements of the tools are similar. Art can be applied with variations in each group's media in hydroponic cultivation.

e. M For Mathematics

Mathematic aspects in project-based learning (PjBL), both on the topic of salt hydrolysis and buffer solutions, related to the ability of students in groups to use mathematics as a tool for calculating in projects.

Table 1. STEAM Aspects

Element	Salt Hydrolysis	Buffer Solution
Science	• Concept regarding salt hydrolysis. • The concept of electrolytes, salt solutions can conduct electricity • Use of alum to purify water	• Concept Buffer solution. • Planting plants using soilless media with nutrients is a buffer solution. • Varying pH to see plant development
Technology	• Electrical conductivity mockups with various modes • The use of parallel and series electric circuits in testing the electrical conductivity of salts.	• Hydroponic agricultural technology
Engineering	• Arrangement of water purifier components with varying arrangements	• The technique of growing water spinach using a hydroponic system, using the planting medium without soil media, only water contains nutrients.
Art	• A wide variety of colors and shapes of mockups • Water purifier with a variety of varying arrangements	• Various forms of growing media in hydroponic plants • Pposters with various shapes and share a mix of colors so that they look attractive
Mathematics	Explain the calculation of the concentration of a salt solution.	Explain the calculation of the buffer solution Timing of planting

For the Water purification project, students can calculate the amount of alum used for a given volume of water. The mathematical element of making mockups of electrical conductivity is found when students calculate the right salt solution concentration for a salt hydrolysis reaction. In hydroponics, mathematical aspects are seen in students' explanations about calculating the pH of the buffer solution and setting planting times.

Based on Table 1, a series of chemistry lessons with the STEAM approach was carried out to analyze 21st-century skills and other implications that arise during learning. Students seemed enthusiastic during learning using the STEAM-PjBL approach, as evidenced by many active students who came forward to provide examples of buffer solutions. This can also be seen from the observer's statement that students play an active role in learning when the teacher asks basic questions about the buffer solution.

The condition of all students in the class is active in expressing opinions; each is about the definition of a buffer. All students actively write acid buffer components and base buffers before class."
(Observation Sheet, Observer 1, 29 March 2017)

The PjBL model is used in this research because project-based learning is a student-centered learning model to carry out an in-depth investigation of a topic [27]. Students constructively deepen their learning with a research-based approach [12]. Designing project planning can bring a sense of responsibility, discipline, cooperation, collaboration, and communication while making students increase creativity and initiative. This can be seen in the following reflective journals:

"The cooperation, help each other help. Because all of them carry out their duties, the cooperation is even more delicious. We need to arrange the tools more easily. The results of the project have become better because of cooperation."
(Student journal *reflective 25, March 1, 2017)*

"By making this project, we can solve problems that appear in life. For example, we live in areas where the water is not clean.
Then, By utilizing available natural materials, we can purify water. So there are materials that can be useful for life....."
(Reflective Student Journal 12, March 3, 2017)

Drawing insights from their reflective journals, students expressed contentment in crafting project designs due to the collaborative nature of the process. This experience also fostered an enhanced environmental consciousness as they created water purification systems. The student cohort embarked on four distinct projects, encompassing the development of models depicting electric conductivity, the fabrication of a water purification apparatus, the cultivation of hydroponic plants, and the formulation of informative posters.

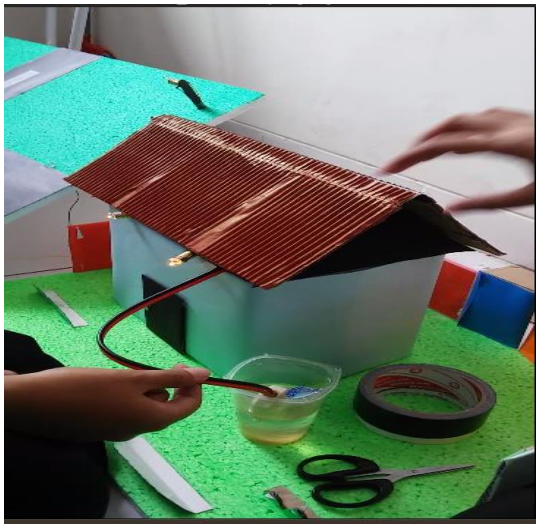

Figure 2. Mockup of Lights in a House (Electrical Conductivity)

Figure 3. Hydroponic plants in various pH

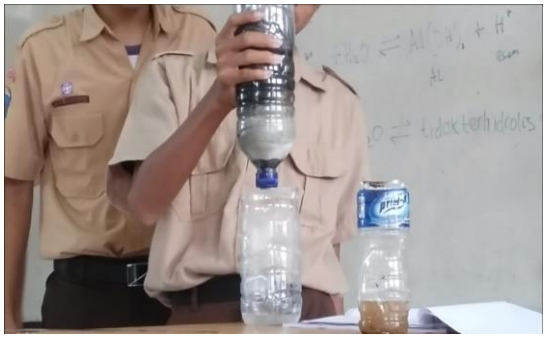

Figure 4. Water Purification Project

Figure 5. Student Presentation Poster

The student's project's outcomes revolve around studying salt hydrolysis and buffer solutions. Figure 2-5 above illustrates the researcher's outline of the learning journey, encompassing stages from formulating essential inquiries to assessing the gained experiences. Assessing learning encounters involves employing interviews and documenting them in reflective journals authored by students. This intends to contemplate the undertaken learning activities, creating a foundation for subsequent learning endeavors.

2. Implications of the STEAM Approach in Chemistry Learning: 21st Century Skills

The implications of the STEAM approach using PjBL can be seen from student interviews, reflective student journals, classroom observations made by observers, teacher diaries, and STEAM questionnaires integrated with 21st-century skills. Through this data, the researcher coded and analyzed the implications of applying the STEAM approach in chemistry learning.

Engaging in chemistry learning through the STEAM approach alongside the PjBL model introduces a novel experience for students, unexplored in their prior encounters with chemistry or under the guidance of other subject educators. This novelty is particularly noticeable in buffer solution and salt hydrolysis. Among the various capabilities showcased by students, their ICT literacy stands out prominently. This discernment is derived from the insights students offer in their reflective journals.

"My skills in using technology and media are also quite helpful in the activities in our group. In the group, I can also adapt to my colleagues."
(Student journal reflective 8, May 5, 2017)

Based on the student's statement, it can be seen that students with STEAM learning are more skilled in using existing technology and utilizing it to benefit project assignments. Incorporating the STEAM approach into chemistry education is anticipated to cultivate essential 21st-century competencies among students [9,23]. Subsequently, the ensuing discourse will delineate the 21st-century skills observed by researchers as a result of implementing the STEAM approach in conjunction with the PjBL model during the process of learning chemistry, specifically focusing on the concepts of salt hydrolysis and buffer solutions:

a. Learning and Innovating Skills

The fundamental competencies of learning and innovation encompass a range of essential skills that students need to cultivate. These include the capacity to exhibit innate creativity throughout the learning process, the skill to innovate existing concepts, the ability to engage in critical thinking to tackle posed challenges, proficiency in both written and oral communication, and the aptitude to collaborate seamlessly with peers for effective information exchange [15].

Derived from observations, interviews, and reflective journals, the assessment of students' performance demonstrated a clear connection between their creative capabilities and innovation during project execution [13]. The subsequent section presents a compilation of student feedback and reviews, shedding light on their experiences and perspectives.:

"*The projects I work on bring out my creativity and motivation, especially when seeing other groups; I feel motivated to make the best possible work."*
(Reflective Student Journal 4, March 8, 2017)

"I am looking for various solutions in determining the pH of the right solution."
(Interview, 21 April 2017)

The reflection of the student journal above, students feel that their creativity and innovation are emerging, and they are also motivated to make the best-assigned work or project [23].

Project-based research makes students creative and innovative because many forms of mockups are made interestingly and uniquely.

Figure 6. Students Making Designs

The STEAM approach makes students creative [13] because a project must contain STEAM elements. Based on Figure 6, critical thinking in the STEAM approach is seen when students are given project assignments, think of ways to function optimally, and think of solutions that must be chosen to solve problems.

The interviews reflective student journals, the integration of STEAM with the PjBL model can make students think critically and be able to solve problems. Here are the

excerpts from interviews and reflective journals:

"The STEAM project that was given helped me analyze various problems in project completion."
(Student interview 17, April 21, 2017)

"I was also trained to think critically and solve problems. Previously, our group didn't plan to use sand when working on a work plan. "
(Reflective student journal 31, March 8, 2017)

It can be seen that the existence of the project makes students think critically and train their skills in solving problems [13].

According to the observer, students' communication skills in this study were excellent; collaboration was also good. Figure 7 show all students work together to complete a project, listen, and ask questions if someone has a presentation.

Figure 7. Student Presentation

Based on the reflective journal, students' communication and collaboration skills also develop.

"The skills I get are communication skills with group members, expressing ideas received by the group, and a sense of solidarity when working on mockups."
(Reflective Student Journal 2, March 8, 2017)

From the student's statement above, students feel more skilled in expressing ideas, feel valued by friends, and increase a sense of solidarity, meaning they are more compact in groups when working on projects. This is also by other research, which states that project-based learning makes students more able to communicate and collaborate because doing projects in this lesson requires the contribution of many people and cannot be done alone.

b. Information, Media, and Technology Skills

Information, media, and technology skills must be possessed to respond to the challenges and currents of globalization. These skills consist of the ability for information literacy, media literacy, and ICT or technology literacy. Information literacy skills are students' abilities, which include accessing information effectively, evaluating information obtained critically, using all the information students get from various sources to make decisions or conclusions, and using the information properly and correctly, according to applicable norms and ethics. The reflective results of student journals, students' information literacy skills develop when STEAM is integrated with the PjBL model on the topic of hydrolysis, as follows:

"Technology in STEAM learning is by using the internet to search for various information and smartphones as the medium."
(Reflective Student Journal 7, 8 March 2017)

In the reflective journal above, students progress in information skills using cell phones and the internet to find lesson

information. Media literacy skills are students' abilities, which include students' abilities as well as students' narrative through reflective student journals:

"During STEAM learning, I use technology and media, one of which is using the internet; with the internet, I can find ways that I don't know and look for innovations." (Reflective Student Journal 20, March 8, 2017)

Based on the student's explanation from the journal's reflection above, media skills are good because they use the internet to get ideas and make innovations. So, there is an element of technology and technique from STEAM by looking at these media skills. In addition, the media skills possessed are also creative and care for the environment.

Technological literacy skills are students' abilities, including using technology to research, communicate information, and produce work per prevailing norms and ethics. Based on the reflective results of student journals, it is revealed that:

"My skills when using technology and media are quite familiar; technology is in the mockup, and then each group assembles the technology in the mockup (battery, lamp, cable, etc.). The use of media also helps in making mock-ups. " (Reflective Student Journal 32, March 8, 2017)

Derived from the reflective journal provided, it is evident that students have advanced their information skills through the adept utilization of technology to acquire information pertinent to project-based learning sessions. This progress exemplifies the evolution of 21st-century students' capabilities. This underscores the fact that project-based initiatives cultivate various proficiencies in students, including information literacy, media literacy, and technology literacy. Applying the STEAM approach consistently enhances students' technological literacy, as demonstrated by the hydroponic project incorporated within the learning framework to yield technological outcomes such as cultivating soil-less plants.

c. Life and Career Skills

Life and career skills include flexibility and adaptability, initiative and self-direction, social and cultural skills, productivity and accountability, and leadership and responsibility.

The reflective results of the student journals show that with the application of STEAM using the PjBL model, students can learn flexibly and adaptively, as seen in the student quotes below:

"I can adapt and be flexible because my group mates are also fun and are invited to work together." (Reflective Student Journals 40, March 8th, 2017)

The journal's reflective nature, the PjBL model students can adapt and be flexible through group learning with the STEAM approach. Students feel comfortable in groups because they can work together with others. The reflective results of student journal learning using PjBL make students take the initiative and have the ability to direct themselves [14]. The following are some of the reflective results of the journal, which also show that initiative arises when faced with a problem, as seen in the student quotes below:

"For example, when I didn't know what a mockup was or how to install a series of

lights, I immediately took the initiative to look for it on YouTube."
(Reflective student journal 6, March 8th, 2017)

"Learning with STEAM is fun because it encourages creativity and initiative."
(reflective student journal 18, March 8, 2017)

When working collectively within groups, students commonly exhibit social and cultural competencies; however, these skills are noticeably amplified with the integration of the STEAM approach through PjBL. As gleaned from the reflections shared in students' journals, implementing the STEAM approach via the PJBL model fosters the nuanced enhancement of their social and cultural proficiencies. Corresponding research corroborates this by highlighting how PJBL contributes to the emergence of students' social abilities [14]. This is underscored by the heightened communication capabilities observed in interactions among peers, signifying a more refined state of social aptitude as they engage in dialogues and exchanges.

Skills productivity and accountability are owned by students when learning in groups, with the STEAM approach using PjBL, which is increasingly visible. Being able to produce a product, a project from the assignment given by the teacher, and the product function well through group work can be observed from learning with the STEAM approach using PjBL [15]. It can be seen in the student quotes below:

" I can hone the skills, creativity, and innovations in doing a project that I am working on, and I can also think quickly in solving problems."
(Reflective Student Journal 26, May 5, 2017)

Through project work, students' productivity and accountability abilities are increasingly visible; cohesiveness in groups, mutual respect, and time management are also more visible. Through the STEAM approach and the PjB L model, students can produce products indicating that student productivity becomes visible [16], characterized by various project results on salt hydrolysis and buffer solutions. It can be seen in the student quote below:

“The skills I developed while working on projects were responsibility, time management, and social skills. For responsibility, I learned not to stand still and actively participate in the group. Apart from that, I also learned to carry things that are my responsibility. "
(Reflective student journal 31, March 8, 2017)

The reflective results of the student journals above, the STEAM approach with the PjBL model makes students responsible [15] because they have tasks and responsibilities to complete; if not resolved, it makes students feel ashamed to be left behind with other groups.

d. Motivation

Motivation is a driving force that propels individuals to excel or attain certain objectives. Integrating the STEAM approach with the PjBL model catalyzes student motivation within the learning process, particularly in chemistry. The novelty of STEAM learning for students contributes to this heightened motivation, aligning with existing research that highlights project-based learning as a potent motivator [16,17]. The ensuing insights are derived from reflective journal entries and observational data:

"The projects I work on bring out my creativity and motivation, especially when seeing other groups; I feel motivated to do the best possible work."
(Reflective Student Journal 7, 8 March 2017)

"My feeling is happy, getting new knowledge and information about health. The skills I got are being able to discuss and be more motivating so that I always maintain my health.
(Reflective Student Journal 25, 31 March 2017)

Based on the observer's observations, the students showed their motivation from the screening of mockups, which they had never seen before.

The reflective results of the student journals above, motivation can bring up other things that are very useful for students. Learning with this STEAM perspective for students can increase student motivation; not only that, but the emergence of motivation in learning makes mutual respect and expressing ideas easier. Learning chemistry using the STEAM approach and the PjBL model makes students more curious because STEAM is new to students, making them interested in learning. Here are some student statements:

" I am excited and interested in this article/story/problem about isotonic. Today, I got more insight into isotonic drinks. The skill is to have discussions with group members. "
(Reflective Student Journal 6, 31 March 2017)

" My feeling about learning with the STEAM model is quite interesting; with this learning model, chemistry learning becomes more fun and modern."
(Reflective Student Journal 8, March 8, 2017)

Gauging from the insights shared in the student reflective journal provided, it becomes apparent that students exhibit a distinct fondness for narrative engagement. Additionally, their enthusiasm is palpable when adopting the STEAM approach, primarily due to its dynamic and contemporary nature. The introduction of project-based learning significantly kindles students' curiosity [16,17,18], as evident through their continuous eagerness to comprehend project particulars, its design, objectives, and the mechanics involved.

e. Confidence

Learning chemistry using the STEAM approach and the PjBL model increases students' self-confidence. Students' confidence in the application of the STEAM approach can be seen in some of the student statements below:

"The skills acquired can increase confidence to speak up front and answer questions."
(Reflective Student Journal 16, March 1, 2017)

"The skills that develop are creativity and courage in expressing ideas."
(Reflective Student Journal 8, March 8, 2017)

Based on students' statements from the journal's reflective data above, the *STEAM* approach to learning makes students confident by being more confident in expressing opinions in public and answering questions. If he has good self-confidence, he can certainly develop his existing potential. This is the theory that *STEAM* learning with *model* increases students' self-confidence [16-18]

The study results generally showed student skills development, but some

students seemed less interested because they focused on scores on cognitive aspects. The challenge of developing soft skills arises in the learning process.

CONCLUSION

In a qualitative descriptive study exploring the implementation of the STEAM approach through the PjBL model in chemistry education concerning salt hydrolysis and buffer solutions, findings reveal that this integration fosters a deeper comprehension of buffer solution and salt hydrolysis concepts. STEAM learning amalgamates science, technology, engineering, art, and mathematics, promoting problem-solving and enhancing soft skills in line with the 2013 curriculum's attitude assessment. Project-oriented learning significantly engages students due to its relevance to everyday life and the related chemical principles taught. Crafting electrical conductivity models, water purification devices, and hydroponic plant systems resonates with students, allowing them to create and employ these projects easily. This approach aims to cultivate students' autonomy and capacity to address various environmental issues by applying acquired academic knowledge. Employing the STEAM approach alongside the PjBL model in chemistry education is a refreshing and innovative experience, offering modern and motivating learning experiences. As this strategy introduces novel dynamics to chemistry lessons, students benefit from a fresh pedagogical perspective that encourages creativity, critical thinking, and active engagement. The implications of this approach encompass a broad spectrum of 21st-century skills, spanning learning and innovation, information and technology proficiency, and life and career competencies. Beyond skill development, the study underscores enhanced curiosity, motivation, self-confidence, contextual chemistry understanding, and religious connections. Notably, project-based learning empowers students to explore, assess, interpret, synthesize, and communicate their acquired knowledge, ultimately fostering a heightened enthusiasm for learning.

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