Applying STEAM-Oriented Project Based Learning to Develop Numeracy Skills in English Instruction

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Abstract. This classroom action research aims to find out whether STEAM-based Project Based Learning (PjBL) can improve students' numeracy skills in nonmathematics subject, such as English. This study was conducted in Procedure Text instruction. Two sustainable lifestyle issues, namely Ugly Food and PET Bottleswere used as project themes. Differentiated learning strategy was implemented in Cycle II. The analysis of the non-cognitive assessment showed that STEAM-based PjBL was proven to enhance students' numeracy skills in mathematical reasoning, the use of mathematical tools, and disposition or attitude. The result of this study highlights the possibility of integrating sustainability elements in language education to enhance students' numeracy skills.

Keywords: STEAM, Project Based Learning, numeracy skill, sustainability, procedure text

1 Introduction

The term "numeracy skills" is defined as "the ability to identify, understand, and use mathematics in various situations in everyday life" [1]. These skills are considered an essential life skill, as they enable individuals to contribute actively to society. With proficiency in numeracy, students are able to utilize mathematical concepts to solve a range of problems, including those related to financial management, time management, and data-driven decision-making.

In general, numeracy skills can be defined as the ability to use mathematics to understand and participate in the world around us[2]. Based on this definition, numeracy skills are not just counting skills. More specifically, according to Goos, et.al. [3], numeracy skills include the ability to interpret, analyze and use quantitative information to make data-based decisions in various contexts. This means that in addition to counting, numeracy skills also involve the ability to understand and use mathematical symbols and representations, as well as the ability to think critically about quantitative issues.

Based on the concept of numeracy that goes beyond mathematics, and focuses on the skills of applying mathematics in real-world contexts [2]–[4], strengthening numeracy is not only the responsibility of mathematics teachers. The implication is that a cross-subject numeracy approach is needed. This means that teachers of non-mathematics subjects, including English, need to play an active role in identifying opportunities to strengthen numeracy in their subjects. However, Susanto, et.al.[4] reminded that non-mathematics teachers do not

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necessarily turn into mathematicians. Instead, non-mathematics teachers need to "embed numeracy in the subjects they teach without losing focus on the subject" (p. 8).

It is unfortunate that the results of the Program for International Student Assessment (PISA) 2022 test demonstrate suboptimal numeracy skills among Indonesian students. The analysis of the PISA 2022 results indicates that approximately 71% of students in Indonesia did not achieve the minimum competency level for numeracy. This suggests that the majority of students in Indonesia still face challenges in applying mathematical concepts to solve problems [5].

A similar phenomenon was observed at SMP Negeri 2 Salatiga. As evidenced by the 2022 *rapor pendidikan*, the numeracy skills score was already in the good category, with 75.56% of students having reached the minimum competency. However, this indicated that 24.44% of students had not yet attained the minimum competency level. Further data analysis showed that the possible root of this issue was the quality of teaching-learning process, particularly on how teachers stimulated students' cognitive processes.

One of the reasons for the suboptimal quality of learning that develops students' numeracy skills is the misconception that numeracy only exists in mathematics subjects. In fact, numeracy skills need to be taught in a variety of contexts across subjects in school to be truly useful [6].

To address this challenge, this class action research applied STEAM-based project-based learning (PJBL) approach that enables students to develop knowledge, skills, and attitudes through projects [7], [8]. PjBL can be defined as a project-based learning model that aims to guide students to experience the process of inquiry to develop knowledge, skills, and attitudes [9]. In other words, PjBL emphasizes the importance of projects to actively build students' knowledge [10]. This method has been proven to make students become active students because they are actively involved in exploring, interpreting, synthesizing, and using information to complete the project [11].

Turk and Berman stated that PjBL brings a different feel to learning because it has several distinctive features. First, it focuses on curriculum contact and learner activities that are structured around real-world challenges. Second, learning typically takes place over an extended period of time, at least a week or more. Third, the teacher plays the role of facilitator, guiding students to actively engage in collaborative projects [12]. Finally, it is hoped that this method can encourage students to build knowledge and transfer that knowledge to other situations or projects. Hamidah outlined the steps in more detail as shown in Figure 1 [9].

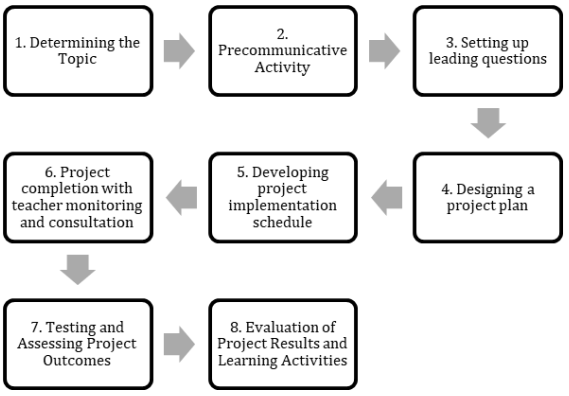

Figure 1. Steps of PjBL in language instruction

STEAM-based learning represents a pedagogical approach that integrates the disciplines of science, technology, engineering, the arts, and mathematics into a unified and comprehensive learning framework. In this context, the arts are integrated with STEM disciplines with the objective of fostering students' creativity, innovation, and critical thinking [13], [14]. In the STEAM approach, innovation and creativity are cultivated through the implementation of practical and contextualized projects, which are designed to equip students with the skills necessary to navigate real-life scenarios [13], [15]. Moreover, the transdisciplinary nature of the STEAM approach enables connections between disciplines that were previously considered distinct. Guyotte et al,. stated that the transdisciplinary nature of STEAM can facilitate students' attainment of a more comprehensive and critical perspective and understanding of the complex real world [15].

Project-based learning (PjBL) and STEAM are two complementary learning approaches. PjBL is a learner-centered approach that encourages active learning, whereas the STEAM approach emphasizes the importance of integrated and interdisciplinary learning. By integrating the two approaches, educators can facilitate learning that is more active, meaningful, and relevant to students' real lives. The compatibility of PjBL and STEAM is corroborated by the findings of previous studies. The implementation of PjBL provides an opportunity for integrated learning through student-directed problem-solving, enabling the creation of a product and/or the acquisition of specific concepts[16]. In addition, integrating PjBL with STEAM was an effective method for enhancing students' comprehension of ecological concepts [17]. Also, it has been argued that PjBL has the capacity to enhance pedagogical strategies and replace conventional teacher-centered learning approaches with student-centered learning [18].

Zayyinah suggested multiple approaches through which educators can integrate PjBL with STEAM [19]. Firstly, educators must integrate scientific, technological, artistic, and mathematical elements into the learning process. Moreover, students must be guided in projects that foster critical thinking abilities. Subsequently, in the context of language learning, it is essential for educators to integrate the four fundamental language skills: reading, writing, listening, and speaking. Finally, the selected project should be authentic and provide students with opportunities to engage in critical thinking.

Thus, in this study, STEAM-based PjBL was employed to enhance students' numeracy skills and learning outcomes in Procedure Text. Specifically, the projects focused on two important themes: Ugly Food (food that is considered ugly but still suitable for consumption) and the problem of plastic waste. By using this STEAM-based, real-world, problem-oriented approach, the students were expected to not only improve their numeracy skills, but also develop a better understanding of the real issues in learning English as a non-mathematical subject. In short, this class action research attempted to investigate whether the application of STEAM-based Project Based Learning can enhance the numeracy skills in procedure text instruction.

2 Research Method

The subjects in this study were 29 students of class IX E in the odd semester of the 2023-2024 academic year, consisting of 16 male students and 13 female students. The students were in phase D of the junior high school level with an age range of 14 to 16 years, or are in the adolescent group.

The object of the study was numeracy skills. According to Susanto et al, nonmathematics teachers are not responsible for conducting numeracy assessment in learning, but can conduct noncognitive assessment in learning [4]. Thus, in this study, students' numeracy skills were measured using noncognitive assessment which includes two things, namely numeracy skills and students' disposition or attitude.

Data was collected in the form of information about the learning process of procedure text using STEAM-based PjBL model, observation results of students' numeracy skills, and learning notes. The data was collected from various sources, including observation notes, notes of discussions and reflections with staff, learning tools in the form of attendance lists, syllabus, teaching modules, attendance lists, and rubrics for non-cognitive assessments. The observation rubric used in this study is as shown in Table 1.

Table 1. Non-cognitive assessment tool of students' disposition [4]

Numeracy Skill	**Yes**	**No**
Mathematical Reasoning		
1. The students understands the mathematical skills needed to solve problems.		
2. The student uses appropriate strategies to find answers.		
3. The student arrives at the correct solution.		
4. The student can explain how the answer is obtained.		
Use of Mathematical Tools		
1. The students choose tools that are appropriate to the problem.		
2. The student can explain the reason for choosing the tool		
3. The student can use tools appropriately		
4. The student can get accurate and precise results from the tools used.		
Disposition		
1. The student seems engaged in learning		
2. The student seems excited and enjoy what he/she is doing		

3. The student tries different approaches (including different tools) to the task in an attempt to find an answer (flexibility of mind)		
4. The student seeks additional information and is willing to try something new and unknown (risk taking)		

The data were analyzed using comparative descriptive techniques. This technique was done by comparing the results between cycles. The indicators in this classroom action research were the improvement of students' numeracy skills in the elements of mathematical reasoning, use of mathematical tools, and dispositions or attitudes as measured by non-cognitive assessments. The research would be considered successful if 80% of the students demonstrate numeracy skills scores above 70% for each element.

3 Result And Discussion

3.1 Initial Condition

The initial condition data showed that the numeracy skills of students had not been optimal, in mathematical reasoning, the use of mathematical tools and disposition. The lowest achievement was seen in the use of mathematical tools. This is because previous English lessons were not designed to provide opportunities for students to use mathematical tools. In addition, the data shows that in the mathematical reasoning section, students have not been able to independently find strategies to solve problems using numeracy. Furthermore, after receiving guidance from the teacher and successfully solving the problem, they were not able to explain how the answer was obtained. The results that were actually quite good could be observed in the disposition. In general, students seemed engaged (68.7%) and excited (58.62%) in learning. However, they have not shown an attitude of willingness to try new approaches to solving problems.

3.2 Cycle I: The Ugly Food Project

The purpose of this lesson is that students can compose food recipes using social functions, text structures and appropriate linguistic elements. The context used is personal and social. Students are invited to examine the problem of Ugly Food, which are fruits and vegetables that are unattractive in appearance but have good quality and are often discarded [20].

3.2.1 Step 1: Setting the topic and precommunicative activities

The lesson begins by introducing the learning topic which is to develop recipes with Ugly Food to reduce food wastage. The teacher triggers students' critical reasoning skills about the potential of wasting Ugly Food by displaying infographics and statistics. This activity is expected to strengthen students' calculation and number reasoning areas through understanding the information presented on the infographic.

3.2.2 Step 2: Setting up Guiding Questions and Designing the Project Plan

At this stage, the teacher asks students a leading question, namely "How can we reduce the food waste by making dishes using ugly food?". This question was asked

to direct students in organizing the project of making a food recipe. Next, students work in groups to design the recipe they will make. Each group consists of 4 to 5 people and students are free to determine the group members.

3.2.3 Step 3: Develop a Schedule for Project Implementation and Project Completion with Teacher Monitoring

In the next meeting, students brought the tools and materials they needed to complete the project. However, before creating the recipe and making the dish with Ugly Food, students were asked to make a plan for task distribution and time estimation. This activity aims to improve students' numeracy skills to estimate and manage time and resources. To help students, the teacher has provided a worksheet as a guide.

3.2.4 Step 4: Testing and Evaluating Project Results

At the end of the lesson, students are asked to test the results of their project through two things, namely tasting the food they have made, and ensuring that the recipes made are in accordance with the provisions. The activity ends with a reflection on the learning process and raises awareness to reduce food waste. A short video of the Ugly Food learning implementation can be accessed through the YouTube application at the link given at Figure 2.

Figure 2. The learning video which can be accessed at https://bit.ly/ugly-food

3.2.5 Discussion of Cycle I

Observation data showed that there was an increase in students' numeracy skills, both in mathematical reasoning, use of mathematical tools and disposition. The highest increase occurred in the use of mathematical tools. The factor that caused this improvement was the learning design that allowed students to use mathematical tools, namely calculators and kitchen scales.

Table 2. Data of Numeration Skills in the initial conditions and cycle I

Noncognitive Assessment	Initial Condition			Cycle I		
	Avg.	≥ 70	%	Avg.	≥ 70	%
Mathematical Reasoning	8.62	0	0	50.9	9	31.03
Use of Math Tools	0	0	0	86.21	29	100
Disposition	37.07	6	20.69	57.76	13	44.83

Table 2 shows the recapitulation of observation data of numeracy skills in the initial conditions and cycle I. The performance indicator of a score of 70 obtained by at least 80% of students was used as a comparison. The data shows that there was a significant increase in the element of using mathematical tools (from 0 to 100%) due to teacher conditioning. Meanwhile, an increase can also be observed in the elements of mathematical reasoning (from 0 to 31.03%) and disposition (from 20.69% to 44.83%). Meanwhile, the increase in the average score also appears consistent in the three elements, namely mathematical reasoning (from 8.62 in the initial condition to 50.9), the use of mathematical tools (from 0 to 86.21) and disposition (from 37.07 to 57.76). However, despite the increase, only the element of using mathematical tools succeeded in meeting the performance indicators (the number of students who achieved a score of more than 70 was more than 80%).

Based on the reflection, there are several things that have gone well. First, students are able to understand complex concepts such as sustainable lifestyle problems, ugly food. Second, they are able to reason critically to understand the ugly food problems around them using the available mathematical knowledge and tools. In addition, students showed better dispositions or attitudes when they worked on hands-on projects or activities that involved active and direct participation through experiments, creative activities, or physical work. Another finding was that creating challenges by limiting resources can actually spark students' problem-solving skills.

However, there are still some things that need to be improved. First, the numeracy content seems to be more dominant than the English content. In addition, secondly, the activities in this first meeting mostly invited students to sit in place. As a result, improving students' attitudes/dispositions towards numeracy reinforcement was not optimal. Third, in this Cycle I, students were allowed to choose their own groups. As a result, teamwork was less effective because some students tended not to concentrate on the project and had an impact on the lack of time allocation that had been provided.

3.3 Cycle II: The Trash Issues

The purpose of this lesson is that students can organize how to make recycled goods from used bottles by using social functions, text structures and appropriate language elements. The context used is personal and social. Students are invited to examine the problem of plastic waste around them. This project is expected to improve critical reasoning character and numeracy skills. The description of the steps is as follows.

3.3.1 Step 1: Determining Topics and Precommunicative Activities

The learning beganwith an outdoor activity. The teacher invited the students to play a garbage sorting game. One student was asked to make a table on the floor using chalk. Meanwhile, other students were given two minutes to pick up trash around them. Then, students were asked to put the waste they have collected into the right column: organic waste or inorganic waste. This activity was expected to improve students' numeracy and critical reasoning skills for classification. Furthermore, students were invited to reflect on the issue of waste around them. The video of this activity can be accessed via the link in Figure 3.

Figure 3. The waste sorting activity

3.3.2 Step 2: Setting up Guiding Questions and Designing a Project Plan

The activity continued in the classroom. After the teacher delivered the English material related to the procedure text, students were asked to design a project plan by making a prototype of a product that could be made using plastic bottles. The prototype was made in the form of a 2-dimensional drawing in pairs.

3.3.3 Step 3: Developing Project Implementation Schedule and Project Completion with Teacher Monitoring

In the next meeting, students were grouped according to their learning readiness level. This means that they were no longer in the same group as the pair that made the 2-dimensional prototype in the previous meeting. So, the first step was to decide which design to use in the group. Then, the teacher distributed worksheets and asks students to plan the amount and type of materials they would need to complete the project. In this project, students could only bring bottles and scissors, and the teacher provided some tools and materials that can be used. This activity was expected to strengthen students' numeracy skills as they have to calculate and estimate the number and types of items needed.

3.3.4 Step 4: Testing and Evaluating Project Results

Students were considered to have successfully completed the project when they successfully created recycled products and procedure texts. In this project, the teacher provided three types of worksheets according to the students' level of readiness. The more prepared the students are, the fewer the number of instructions provided.

3.3.5 Discussion

The data in Cycle II shows that there was a consistent increase in the elements of mathematical reasoning, use of mathematical tools and disposition. When compared to the performance indicators, all met the performance indicators as indicated by more than 80% of students achieving a score above 70 (82.76% on mathematical reasoning, 100% on the use of mathematical tools, and 82.76% on disposition). The highest average increase occurred in the use of mathematical tools (from 0 in the initial condition to 90.52 in cycle II), followed by mathematical reasoning (from 8.62 to 74.1 in cycle II), and disposition (from 37.07 to 72.41 in Cycle II).

Table 3. Data of Numeration Skills in initial condition, cycle I and cycle II

Noncognitive Assessment	Initial Condition			Cycle II			Cycle II		
	Avg.	≥ 70	%	Avg.	≥ 70	%	Avg.	≥ 70	%
Mathematical Reasoning	8.62	0	0	50.9	9	31.03	74.1	24	82.76
Use of Math Tools	0	0	0	86.21	29	100	90.52	29	100
Disposition	37.07	6	20.69	57.76	13	44.83	72.41	24	82.76

There were several things that had gone well in this cycle. Firstly, students were able to grasp big concepts such as circular economy when they were actively involved in solving problems through hands-on activities. In addition, students did not experience significant difficulties when completing projects with engineering elements such as creating two-dimensional prototypes. In addition, implementing differentiated learning by providing three types of worksheets according to students' learning readiness level helped improve numeracy skills according to students' needs and characteristics. Secondly, challenging students to work on projects using limited resources was proven to improve their problem solving and critical thinking skills. All in all, the study showed that the integration of STEAM and PjBL can develop critical and creative thinking skills, problem solving skills, collaboration, argumentation skills, and student responsibility. The integration of STEAM in this lesson is summarized in Table 4.

Table 4. STEAM integration in the lessons

STEAM elements	Description
Science	Students calculate potential food waste in Jakarta based on statistics and infographics, and solve real-world problems about sustainability, such as how to recycle PET bottles sustainably.
Technology	The integration of technology is seen in the activities of using scales, measuring cups, and spoons to weigh and measure ingredients in making recipes, as well as the use of modern tools and materials to support STEAM learning.
Engineering	Engineering activities are seen in the prototyping project as well as making dishes on a budget and without the use of a stove. students are faced with the challenge of designing recipes that meet criteria while taking into account resource limitations.
Art	Art is involved in creating two-dimensional prototypes from plastic bottle waste and hands-on activities such as collecting and sorting bottles, and creating recipes. In addition, students' creativity is explored in presenting their solutions and ideas.
Mathematics	Mathematical skills are applied in various aspects, including calculating potential food wastage, planning a budget for creating dishes from Ugly Food, and solving the

	challenge of creating recipes with a limited budget and set time.

4 Conclusion

This Classroom Action Research aims to improve students' numeracy skills through the application of STEAM-based Project Based Learning on procedure text material for students of class IX-E SMP Negeri 2 Salatiga in the 2023-2024 academic year. The reflection results show that the application of STEAM-based PjBL in nonmathematics learning is proven to improve students' numeracy skills, especially in mathematical reasoning, the use of mathematical tools, and disposition or attitude. The improvement seemed to be more optimal in cycle II which applied the process differentiation strategy using worksheets with tiered difficulty levels.

This improvement is consistent with the results of previous research which states that PjBL and STEAM can improve students' critical reasoning skills and creativity by sparking them to solve actual problems in the real world, which in this class action research is displayed in the themes of Ugly Food and Trash (PET Bottles) Issues.

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