Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika
https://journal-center.litpam.com/index.php/e-Saintika/index

July 2025 Vol. 9, No. 2
e-ISSN: 2615-6881
pp. 363-378

Project Based Learning with Socio Scientific Issues in Improving Junior High School Students' Habits of Mind on Biotechnology Material

* **Kartika Nahdiyati, Mimin Nurjhani Kusumastuti, Siti Sriyati**

Biology Education Department, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229 Bandung 40154, Indonesia

*Corresponding Author e-mail: muhammadiqbal@undikma.ac.id

Received: May 2025; Revised: June 2025; Published: July 2025

Abstract

The development of science and technology requires students to have Habits of Mind (HoM) to be able to think critically, creatively, and reflectively in dealing with complex problems. This study aims to determine the effect of the Socio-Scientific Issues-based Project-Based Learning (PJBL-SSI) model on changes in students' HoM on biotechnology material. Socio-Scientific Issues context, such as gluten-free diet trend, was chosen to encourage real problem-based learning and project-based decision making. The study used a quasi-experimental method with a Non-equivalent Control Group Design, involving 62 ninth grade students in Bandung City Public Junior High School. The experimental group received PJBL-SSI learning, while the control group used conventional PJBL. Data were collected through validated HoM pretest and posttest questionnaires. The results showed an increase in the mean score of HoM in the experimental group from 38.23 to 44.97, while the control group decreased from 41.62 to 40.90. The Mann-Whitney U test showed a significant difference between groups ($p = 0.006$). These findings support previous studies that the integration of PPA and SSI is effective in shaping students' reflective and critical thinking dispositions through contextual projects and meaningful ethical discussions.

Keywords: Project-Based Learning; Socioscientific Issues; Biotechnology; Gluten Free Diet; Gluten Free Bread

How to Cite: Nahdiyati, K., Kusumastuti, M. N., & Sriyati, S. (2025). Project Based Learning with Socio Scientific Issues in Improving Junior High School Students' Habits of Mind on Biotechnology Material. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *9*(2), 363–378. https://doi.org/10.36312/e-saintika.v9i2.3216

https://doi.org/10.36312/e-saintika.v9i2.3216

INTRODUCTION

The development of science and technology has had a significant impact on daily life, including the emergence of various complex problems in the health sector, as well as social and economic life (Wiyarsi et al., 2021). This condition requires individuals to be able to think and behave appropriately in making decisions. The ability to behave and think appropriately is very important to prepare smart citizens and make wise decisions (Ongardwanich et al., 2015). One important skill in this context is habits of mind, which are reflective and productive thinking habits that play an important role in the decision-making process (Wu & Tsai, 2011).

The concept of habits of mind originated from research in education and brain development. The HoM concept includes habits of mind that develop through conscious practice and meaningful experiences (Gardner, 2011). Habits are described

as almost instinctive behaviors, which provide the mental space to be able to solve problems without the need to choose a particular type of thinking to use (Alhamlan et al., 2017). Meanwhile, Costa & Kallick (2000) explain that habits of mind relate to a set of tendencies that are learned and practiced before a person can complete a certain set of tasks with ease.

Learning according to Marzano et al. (1993) incorporated habits of mind into the framework of learning dimensions, especially the first dimension (attitudes and perceptions towards learning) and the fifth dimension (productive habits of mind), which are important foundations for the success of other dimensions. This is because when students have positive attitudes and perceptions, as well as good habits of mind, they tend to be easier in the learning process and able to absorb more knowledge (Mulvia et al., 2021). HoM is categorized into three groups, namely: self-regulation, critical thinking, and creative thinking (Marzano et al., 1993).

Critical thinking is an ability that involves students in improving reasoning and problem solving (Sukmadinata, 2011), while self-regulation is a skill that emphasizes the importance of personal responsibility in controlling the knowledge and skills acquired, and creative thinking is a skill to observe problems or situations from a new perspective which means unorthodox solutions (which may seem unsettling at first) (Gafour & Gafour, 2020). Students who have good thinking habits tend to have superior problem solving skills (Mulvia et al., 2021). This is because the problem-solving process involves reasoning as well as the application of knowledge that utilizes skills, attitudes, insights, personality, previous experiences, and various other superior dispositions, all of which are included in the concept of habits of mind (Hizqiyah et al., 2019; Hayat et al., 2019).

Project-based learning (PjBL) has been widely recognized as a constructivist pedagogical approach that provides space for students to construct meaning through authentic and collaborative experiences. Mardhatillah et al. (2025) study by showed that the integration of PjBL with digital teaching and computational thinking had a positive impact on improving students' HoM. However, most PjBL studies such as Evcimik & Oruc (2023) only focus on strengthening moral and cognitive values, without exploring sociocultural aspects or the context of real issues.

On the other hand, the Socio-Scientific Issues (SSI) approach has been widely used to improve students' scientific literacy and critical attitude towards global issues (Sadler & Zeidler, 2005). Studies by Wiyarsi et al. (2021) and Küçükaydin (2022) show that SSI is able to foster scientific habits of mind, but the implementation of SSI is usually still discursive, not yet integrated in an applicable project model. In a systematic review by Hernández-Ramos et al. (2021), problem-based learning and technology often include SSI, but not many have integrated it fully in the context of PjBL and HoM.

Recent research has demonstrated the effectiveness of Project-Based Learning (PjBL) integrated with Social Scientific Issues (SSI) in improving various student skills. Research shows that PjBL with SSI can significantly improve students' critical thinking skills, especially in problem solving and decision making (Fitriyani et al., 2025). This approach also proved effective in improving the creative thinking skills of fourth grade students (Sri Rezekii & Nugraha, 2024). PjBL also showed a positive impact on the development of social skills, including the ability to take turns, respect, and emotional control (Qitfirul & Izza, 2023). Furthermore, a comparative study revealed

that SSI-based STEM PjBL showed promising results in improving science literacy among biology education students (Anggereini et al., 2023). These findings collectively suggest that SSI-integrated PjBL is a versatile and effective pedagogical approach to develop critical thinking, creativity, social skills and science literacy across different levels of education.

Integrating Socio-Scientific Issues (SSI) into Project-Based Learning (PjBL) is deemed suitable, as SSI reflects societal concerns that are closely connected to scientific topics (Reswara et al., 2024). Socioscientific issues are generally characterized by scientific developments or processes that give rise to public discourse or controversy. Contemporary examples of such issues frequently originate from breakthroughs in biotechnology, including cloning, stem cell research, and genetically modified organisms, as well as from pressing environmental concerns such as global climate change, land-use policy, and the introduction of non-native biotic and abiotic agents (Sadler & Zeidler, 2005). The study by Owens et al. (2021) shows that the successful implementation of SSI instruction requires the application of core science teaching practices and includes unique additional practices that serve to enhance students' ability to apply science learning to controversial issues that require them to be able to make informed decisions.

Biology is one of the fields of science that emphasizes real scientific process skills, mastery of concepts based on rational and scientifically proven findings. The use of educational topics derived from everyday and societal issues—such as health, food, and energy—enables students to develop an awareness of the relevance and significance of understanding scientific phenomena and technological challenges (Broman et al., 2018). In this study, the socioscientific issue used in learning is the gluten-free diet trend that will be associated with conventional biotechnology materials. Gluten-free diets were introduced for the treatment of celiac disease as early as 1941, as reported by pediatrician Willem Karl Dicke, and are still used for the management of this disease (van Berge-Henegouwen & Mulder, 1993). But over the past decade, the gluten-free movement has exploded in popularity and is increasingly common among the public (Newberry et al., 2017). This transition raises questions about its efficacy, benefits and potential drawbacks for those without medical reasons to avoid gluten. As it gains a growing following, it is important to dissect whether this diet is a friend that provides tangible health benefits to a wider audience, or an enemy, potentially leading to malnutrition or other unintended consequences (Jwala, 2024). The diet can be considered a momentary fad, with its popularity driven more by marketing and misconceptions than by solid scientific evidence.

This approach of PjBL with SSI is aligned with Mezirow's transformational learning theory, which emphasizes perspective change through critical reflection on authentic experiences. SSI-based PJBL creates a learning space where students engage in evidence-based decision-making, consider ethical and social aspects, and reflect on their initial beliefs - a core process of cognitive transformation (Mezirow, 2008). Furthermore, this approach also reflects Freire's critical pedagogy, where education is positioned as a tool of liberation. By raising issues such as gluten-free diets, which are fraught with scientific and social controversies, students not only learn science but also participate in praxis: thinking, acting, and reflecting back on the meaning of those actions in their social context.

Although PjBL and SSI have each been shown to be effective in improving higher order thinking skills, there is a significant gap in the literature: not many studies have explicitly combined PjBL and SSI as an integrated strategy for developing Habits of Mind. Gossard et al. (2023) redesigned a HoM-based curriculum, but did not link it to SSI contexts or concrete projects. With these theoretical and empirical foundations, this research is expected to contribute to the development of innovative learning models that not only improve students' cognitive competencies, but also foster reflective, critical, and meaningful habits of mind in dealing with real issues in society. This is potentially able to develop students' HoM comprehensively, in accordance with the demands of 21st century education.

METHOD

Research Design

This study used a Non-equivalent Control Group Design. This study involved administering a treatment to the experimental group, while a control group was used for comparison purposes (Creswell, 2014). The term non-equivalent is used because the two sample groups are not equivalent groups or equal in all respects or aspects, but only equal in some aspects (Isnawan, 2020). In this study, the two groups have in common that they are classes at the same level.

Before the learning process began, the subjects were given a questionnaire to measure habits of mind (pre-respond). Furthermore, students follow project-based learning with socioscientific issues on biotechnology material. After the learning is complete, students will be given a questionnaire again to assess the improvement of habits of mind (post-respond). The research design was used as in Table 1, whereas O1: initial questionnaire of Habits of Mind and digital literacy of students (pre-response); O2: final questionnaire of Habits of Mind skills (post-response); X1: learning biotechnology material using PJBL-SSI model; X2: learning biotechnology material using PJBL model.

Table 1. Research Design

Group/class	Pre-respond	Treatment	Post-respond
Experimental	O1	X1	O2
Control	O1	X2	O2

Sample/Participant

The population in this study were 9th grade students in one of the public junior high schools in Bandung City, with a sample of 2 classes (62 students) who took part in learning biotechnology using the Project-Based Learning (PjBL) model with socioscientific issues. The sample selection was done by purposive sampling, by considering certain criteria. These criteria include students who have personal communication devices such as gadgets, have relatively homogeneous cognitive abilities, are accustomed to using gadgets, and are able to access and utilize the internet.

Instrument and Procedures

This research employed quantitative data collected through non-test instruments, including questionnaires and observation sheets. The questionnaire was designed to assess students' habits of mind, while the observation sheet was used to

evaluate the implementation of the project-based learning model incorporating socioscientific issues during classroom activities. The Habits of Mind instrument was developed based on the indicators proposed by Marzano et al. (1993). It took the form of a weighted multiple-choice questionnaire with four response options per item, each assigned a weight corresponding to its alignment with the targeted indicator. The questionnaire underwent validation to ensure its reliability and validity. It was administered to students both before the instructional intervention (pre-response) and after its completion (post-response). The instrument blueprint is presented in Table 2.

Table 2. Habits of Mind Instrument Grid

Variable	Indicators
Creative thinking	a. Engage intensely in tasks even when answers or solutions are not immediately apparent b. Establishing, believing in, and maintaining personal standards of evaluation c. Develops new ways of achieving standards
Critical thinking	a. Being accurate and seeking accuracy b. Being clear and seeking clarity c. Being open-minded d. Taking and defending a position e. Being sensitive to others
Self-Regulation	a. Being aware of one's own thinking b. Plans effectively c. Knows and uses necessary sources of information d. Responds appropriately to feedback e. Evaluating the effectiveness of one's own action

In this study, Habits of Mind are understood as cognitive-reflective dispositions formed through meaningful learning experiences. HoM is considered a thinking tendency that can be measured through repeated and consistent behaviors in the context of problem solving (Fletcher, 2023).

The instrument has been validated by three experts and tested on 32 respondents to obtain validity and reliability data. The results of the correlation test between items showed that 12 out of 14 items had a significant correlation with the total score ($r \geq 0.349$; $p < 0.05$). The reliability test using Cronbach's Alpha resulted in a value of 0.881, indicating that the instrument has high internal consistency. This indicates that the questionnaire is suitable for use in data collection.

The treatment in this study involved implementing the PjBL-SSI approach in the experimental group, while the control group received instruction using the standard PjBL model. The PjBL framework consists of five key phases: initiating with a driving question, developing a project plan, creating a timeline, monitoring students and project progress, evaluating the final product, and reflecting on the overall experience. The distinctions between the PjBL-SSI approach used in the experimental group and the conventional PjBL applied in the control group are outlined in Table 3.

Table 3. PjBL Syntax in Control and Experiment Classes

Syntax	PjBL-SSI	PjBL
Start with the big question	Present the context of the socioscientific issue being studied: *The Gluten in Food Controversy: Between Food Needs and Public Health*	Open learning with the question "what are the products of biotechnology in everyday life?"
Design a plan for the project	Learners consider different alternatives for making gluten-free bread. After finding relevant information, learners decide which product to make.	Learners write down the tools and materials and work steps for making gluten-free bread.
Create a schedule	Students analyze the needs of the project by looking back at the gluten- free bread product to be made.	Students compile a schedule for making products according to a predetermined time.
Monitor the student and the progress of the project	Students carry out the project independently by listing the progress of the project on the e-LKPD and identifying errors while making the project.	Students carry out the project independently.
Assess the outcome	Students present the gluten-free bread products made along with the e- LKPD done during the project.	Students present the products made
Evaluate the experience	Learners do a self-evaluation of the actions taken during the project to help them learn from mistakes.	Learners Learners reflect in groups on a series of learning activities using the *Project based learning*.

Data Analysis

The implementation of project-based learning in the experimental class was assessed using an observation sheet filled in by the teacher observer. The observation sheet was prepared based on the syntax of PjBL as regulated by the Ministry of Education and Culture (2014). The grids of the PjBL implementation observation sheet were adapted from Astuti (2015) research. The assessment of learning implementation was carried out using a Likert scale with five levels of assessment, namely: score 1 for activities that did not match at all with the observed aspects, score 2 for activities that were less appropriate, score 3 for activities that were appropriate, score 4 for activities that were very suitable for the observation indicators (Arikunto, 2013). The results of the observation sheet were then calculated and interpreted into categories as in Table 4.

Table 4. Categorization of Habits of Mind and Learning Implementation

Category	Percentage (%)	Description
A	85-100	Very good
B	70-85	Good
C	55-70	Fair
D	40-55	Deficient
E	0-40	Very Poor

Ethical Statement

This research also pays attention to ethical aspects. Official permission was obtained from the school, and student participation was voluntary. The confidentiality of the data and the identity of the participants were well maintained during the research process.

RESULTS AND DISCUSSION

Descriptive Analysis of Habits of Mind Scores

The results of descriptive analysis of the ability of habits of mind in students are in Table 5. Based on Table 5, there is a change that shows an increase in the emergence of students' habits of mind response after applying the PjBL-SSI learning model. The average score of habits of mind in the PjBL-SSI group increased from 38.23 in the preresponse to 44.97 in the postresponse. This reflects that students began to show more positive habits of mind behavior. In addition, the increase in minimum (from 29 to 32) and maximum (from 44 to 55) scores showed that improvement occurred evenly among both low and high ability students.

Table 5. Descriptive Statistics

Statistic	PjBL-SSI		PjBL	
	Pre-response	Post-response	Pre-response	Post-response
Minimum Score	29	32	32	29
Maximum Score	44	55	50	49
Mean	38.23	44.97	41.62	40.90
Standard Deviation	4.34	5.58	4.67	4.47
Sample Size	31	31	31	31

In contrast, in the PjBL group without the SSI approach, the average score actually decreased slightly, from 41.62 to 40.90. The minimum score decreased from 32 to 29, and the maximum score also decreased slightly from 50 to 49. This indicates that the students' habits of mind response did not develop significantly, and even tended to stagnate or regress.

Comparative Analysis of Habits of Mind Indicators

Based on the data in Table 6 and Table 7, we can see the difference between the experimental class that applied PJBL-SSI learning and the control class that only used conventional PJBL. At the initial stage (pre-response), the average Habits of Mind score of learners in the experimental class was in the "Fair" category, namely Creative thinking (2.69), Critical thinking (2.72), and Self-regulation (2.75).

Tabel 6. Average Habits of Mind Indicators in Experimental Class using PjBL-SSI Learning

Habits of mind indicators	Pre-response score	Categories	Post-response score	Categories
Creative thinking	2.69	Fair	3.24	Good
Critical thinking	2.72	Fair	3.18	Good
Self-regulation	2.75	Fair	3.24	Good

In contrast, learners in the control class have shown higher initial scores, all of which are in the "Good" category, with the score of each indicator, namely Creative thinking (2.90), Critical thinking (3.04), and Self-regulation (3.01). This indicates that the initial condition of the control class is generally superior in the Habits of Mind aspect compared to the experimental class.

After treatment, there was an increase in scores in the experimental class. All indicators rose to the "Good" category, with Creative thinking and Self-regulation scores of 3.24 and Critical thinking of 3.18. This increase shows that the PJBL-SSI approach is able to encourage students to develop creative, critical thinking habits and self-regulation skills better. Meanwhile, in the control class, although the Creative thinking indicator experienced a slight increase from 2.90 to 3.01 (still in the "Good" category), there was a decrease in Critical thinking (from 3.04 to 2.87) and Self-regulation (from 3.01 to 2.92), although both were still in the "Good" category.

Tabel 7. Average Habits of Mind Indicators in Control Class using PjBL Learning

Habits of mind indicators	Pre-response score	Categories	Post-response score	Categories
Creative thinking	2.90	Fair	3.01	Good
Critical thinking	3.04	Fair	2.87	Good
Self-regulation	3.01	Fair	2.92	Good

Hypothesis Testing Results

Further hypothesis testing was conducted using the non-parametric Mann-Whitney U Test to see the difference in Habits of Mind between the experimental class (PJBL-SSI) and the control class (conventional PJBL). Based on the analysis results in Table 8, the Asymp. Sig. (2-tailed) value of 0.006, which is smaller than the significance level of 0.05. This shows that there is a statistically significant difference between the two groups after the treatment. Thus, it can be concluded that the PJBL learning model based on Socio-Scientific Issues (PJBL-SSI) has a significant effect on improving students' Habits of Mind.

Tabel 8. Hypothesis Test of Students' Habits of Mind using Mann-Whitney U Test

Test Statistics	Value
Mann–Whitney U	286.500
Z	-2.741
Asymp. Sig. (2-tailed)	0.006

Theoretical and Empirical Support for PJBL-SSI Effectiveness

This improvement can be explained through current theory and practice on learning that fosters students' intellectual disposition. Fletcher (2023) states that Habits of Mind do not emerge automatically, but are formed through explicit processes in learning that make room for reflection and active engagement. In the context of PJBL- SSI, students are not only asked to complete project tasks, but also invited to consider real issues such as gluten free, which are related to social, health and science aspects. This encourages emotional engagement and deep thinking.

Studies by Nolan & Zeidler (2025) show that student engagement in SSI-based learning is able to encourage critical reflection, which is the basis of perspective change and deeper thinking. This reflection is very relevant to the habits of mind,

especially in the aspects of self-regulation and critical thinking. PJBL-SSI not only presents the project as a final product, but also as a reflective, social, and emotional thinking process. Research by Ospankulova et al. (2025) also confirmed that the application of PjBL in science education increases students' emotional engagement and develops a positive attitude towards learning. This is in line with the results of this study, which showed that students who engaged in PjBL-SSI experienced an increase in HoM, as they not only learned the content, but also related it to social realities that demanded position taking, justification, and ethical management of emotions.

Furthermore, the PjBL-SSI approach is very much in line with Mezirow's transformative learning theory, where students experience a disorienting dilemma when faced with information that challenges their initial thinking, and through critical reflection, they construct new meanings that are more inclusive and rational. Students who initially only saw gluten-free diets as a health trend, for example, began to consider the nutritional, economic and social impacts of the practice. This process demonstrates engagement in deep habits of mind-self-regulation, critical thinking, and creative thinking in a social context.

Similarly, through the lens of Freire's critical pedagogy, PJBL-SSI enables students to experience conscientization-critically realizing their social reality and acting to change it. Learning is no longer a one-way process of knowledge transfer, but a dialogue between students, social issues, and science that forms agents of change. Thus, PJBL-SSI not only promotes cognitive achievement, but also makes students more aware and reflective of their choices and attitudes, as found in the study by Irwandani et al. (2025), which showed the strengthening of critical thinking skills in student teachers through SSI-based collaborative learning.

Student Reflections and Qualitative Insights

The effectiveness of the PJBL-SSI approach in this study is not only reflected in the increase in the quantitative Habits of Mind score, but also reinforced by students' qualitative reflections that show emotional engagement, creative solutions, and metacognitive awareness. These reflections illustrate that students did not simply complete project tasks, but rather experienced a personally and socially meaningful learning process.

Some students demonstrated the ability to overcome obstacles independently with adaptive approaches. For example, Respondent 1 stated: "*It was difficult to find sticky rice flour, so my solution was to buy it elsewhere and look for replacement information on the internet*." This statement reflects aspects of self-regulation and information-based solution seeking, one of the main characteristics of HoM which emphasizes independence of thought and the ability to find alternatives when facing problems.

Collaborative and emotional management aspects also emerged in the group dynamics. Respondent 2 revealed: "*The group was really difficult to organize... but eventually we were able to work together because we reminded each other and kept trying*." These reflections demonstrate the processes of social negotiation, tolerance and resilience that developed during the project - important dimensions in project-based education that emphasize shared responsibility and group decision-making.

In addition, some students began to interpret the project as functional and relevant to real life. This can be seen in Respondent 3's statement: "*So we can make this*

sponge bread on other days, for example selling or during family events." and Respondent 4: "*I know how to make gluten-free products and know which ingredients are suitable or not.*" These reflections indicate that students not only understand science concepts, but also relate learning to their social, economic and personal contexts.

This finding strengthens the role of PJBL-SSI in fostering holistic scientific thinking dispositions. Project-based learning with a socioscientific context not only strengthens concept understanding, but also provides space for students to experience, reflect, and internalize scientific and social values simultaneously. This is in line with the study of Sa'ban et al. (2023) which states that engagement in real issues encourages students to develop Habits of Mind through authentic experiences that are cognitively and emotionally challenging.

Worksheet Activity Analysis

The activities displayed in the worksheet show that the learning process through the gluten-free bread making project has encouraged the development of students' Habits of Mind in a real way. In the "Answer Questions" section in Figure 1, students demonstrate critical thinking skills when answering science literacy-based questions, such as understanding the health risks of a gluten-free diet or the economic implications of the trend. This indicates that students are not only memorizing information, but also assessing and evaluating contextually.

Creative thinking skills are illustrated in the "Find Your Idea!" section in Figure 1, where students developed product ideas based on data, such as choosing "gluten free banana bread" with rice flour substitution. They were also able to identify the advantages and disadvantages of the ingredients, as well as propose texture solutions with logical arguments, reflecting the innovative process in decision making.

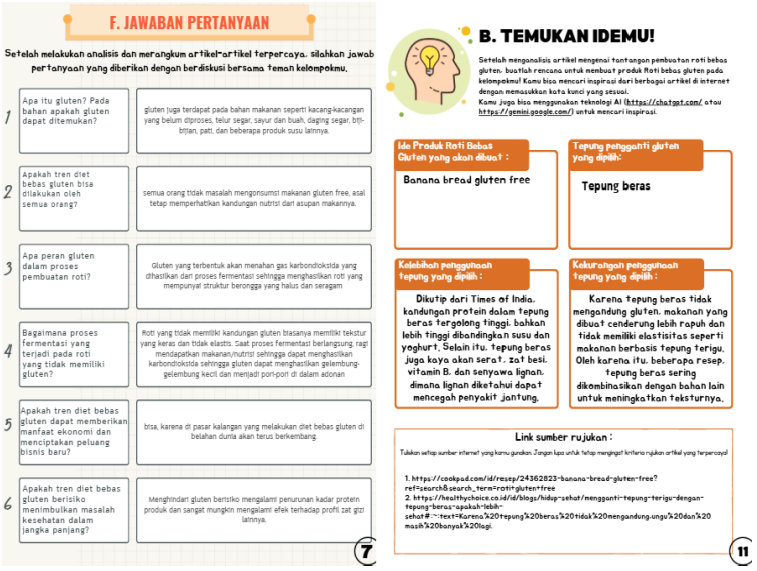

Figure 1. Question Answer and Find Your Idea sections

Meanwhile, self-regulation indicators were strongly visible in "Group Reflection" and "Project Analysis" in Figure 2. For example, when students evaluated technical errors such as the dough being too liquid, or difficulty finding a mold, they showed a reflective attitude and responsibility for the process. Solutions such as "better prepare the ingredients and follow the recipe" reflect metacognitive awareness and independent re-planning for future improvements.

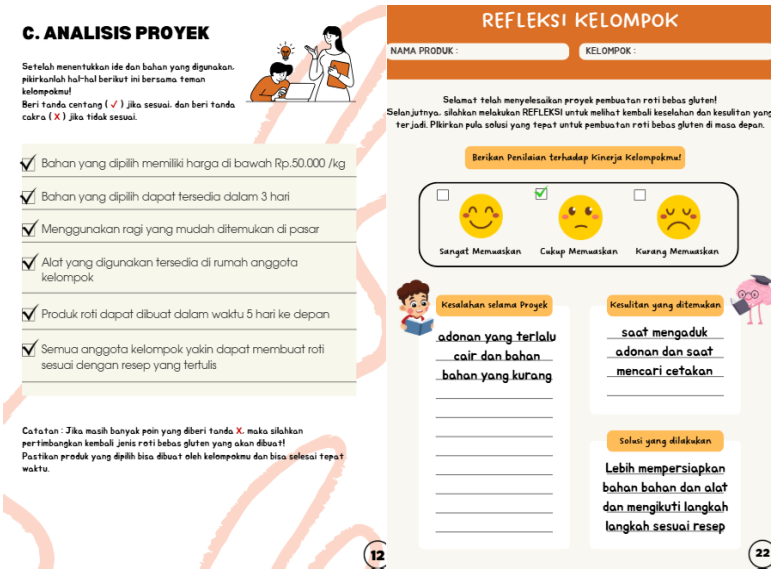

Figure 2. Project Analysis and Group Reflection Section

Another study by Wiyarsi et al. (2021) found that integrating social scientific issues in learning improves students' scientific habits of mind. In this context, students learn to analyze and assess information and develop strategies to understand complex issues, namely gluten free diet. This suggests that through SSI-focused project-based learning, students can develop better mental resilience and problem-solving skills (Daniel, 2017). Approaches that involve social scientific issues are able to provide more meaningful challenges, thus encouraging learners to think critically, creatively, and learn to manage themselves in the learning process. Students who engage in scientific social issue-based learning model not only learn the application of science, but also understand the social and ethical implications of scientific decisions taken (Durak & Topçu, 2021).

Observation of PJBL-SSI Implementation

The results of observations of the implementation of learning PJBL based on Socio- Scientific Issues (PJBL-SSI) showed in Table 9. It showed that both teacher activities and student activities were in the Very Good category. The average implementation of teacher activities was 95.82%, while student activities reached 94.52%. This high average value reflects the optimal implementation of learning, characterized by the teacher's role as an active facilitator and consistent student involvement throughout the learning process. Overall, teacher and student activities showed a stable and high trend at each meeting. The decrease in scores seen in the fourth meeting, both in teacher and student activities (87.5%), can be explained through the context of learning activities in that session, namely the syntax of "supervising the course of the project" carried out by students individually at their respective homes. Because this activity took place outside the classroom, the intensity of direct observation of face-to-face interactions was lower, which had an impact on the observation results. Nevertheless, the implementation score at this meeting remained in the "Good" category, and increased again significantly at the fifth meeting.

This high implementation of learning indicates that the PJBL-SSI approach was implemented consistently in accordance with its syntax design. The success of PjBL is

highly dependent on the role of the teacher as a facilitator and student activities as project implementers. This is in line with the opinion of Ratnawati et al. (2024) who emphasized that the successful implementation of PJBL is highly dependent on the teacher's ability to design effective learning and provide support and motivation to students in the project completion process. Active interaction between students and teachers in PjBL plays a role in creating meaningful learning experiences. When students work in groups to complete projects, they not only understand academic content but also develop important skills such as problem solving, time management and social skills. Their active involvement in learning promotes a sense of responsibility and ownership of their learning process (Sa'adah & Pertiwi, 2022). This shows that the success of PjBL lies not only in the end result of the project, but also in the journey that students go through during the learning process. Thus, it can be concluded that the implementation of PJBL-SSI that runs very well also supports the improvement of students' Habits of Mind, because they are actively involved in investigating, making decisions, and reflecting on real issues that are relevant to their lives.

Table 9. Observation Results of Implementation of PjBL-SSI Learning

Meeting	Teacher Activity	Student Activity
1	97.4	97.2
2	97.2	97.7
3	97	93
4	87.5	87.5
5	100	97.2
Average	95.82	94.52
Category	Very good	Very good

Limitations

This study has some limitations. First, the use of self-report instruments to measure HoM has the potential for bias because it only reflects students' perceptions, not actual behavior. Qualitative observation instruments or written reflections can be complementary alternatives to explore the process dimension. Second, the research subjects were still limited to two classes with homogeneous contexts. Further research can involve schools with more diverse social backgrounds or different SSI theme contexts, such as environmental issues or bioethics. In addition, the effectiveness of PJBL-SSI can be further explored through a longitudinal approach, to see if its influence on HoM persists in the long term. It is also recommended to develop a portfolio-based HoM assessment instrument, so that students' thinking processes can be seen more authentically and dynamically.

CONCLUSION

This research shows that the Socio-Scientific Issues-based Project-Based Learning (PJBL-SSI) model is significantly more effective in improving students' Habits of Mind (HoM) than conventional PJBL. All HoM indicators-creative thinking, critical thinking, and self-regulation-experienced an increase in category from "sufficient" to "good", with statistically significant differences ($p = 0.006$). The effectiveness of PJBL-SSI was influenced by students' active involvement in a

contextualized project (gluten-free diet) that encouraged critical thinking, reflection, and cooperation. Students' reflections showed that this learning fostered resilience, a sense of responsibility, and the ability to solve problems independently.

The high implementation of learning indicates that PJBL-SSI can be optimally implemented in schools. Thus, the integration of PJBL and SSI not only strengthens conceptual understanding, but also forms sustainable scientific thinking habits. The implication of this finding shows the importance of the teacher's role in designing meaningful and contextualized learning so that students are able to face real-life challenges with higher order thinking skills.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that educators incorporate the Project-Based Learning model integrated with Socio-Scientific Issues (PJBL-SSI) into science instruction, particularly in topics that intersect with real-world issues such as biotechnology, health, and the environment. This approach not only facilitates contextual learning but also promotes the development of students' Habits of Mind, including critical thinking, creative thinking, and self-regulation. Teacher training programs should include strategies for designing and implementing PJBL-SSI effectively in diverse classroom settings. Future research is encouraged to explore the long-term impact of PJBL-SSI on students' cognitive and affective outcomes across different grade levels and subject areas. In addition, the integration of digital tools in PJBL-SSI could be investigated to enhance student engagement. and collaborative learning.

Author Contributions

Conceptualization, K.N. and M.N.K.; methodology, K.N.; software, not applicable; validation, K.N., M.N.K., and S.S.; formal analysis, K.N.; investigation, K.N.; resources, M.N.K.; data curation, K.N.; writing—original draft preparation, K.N.; writing—review and editing, M.N.K.; visualization, K.N.; supervision, S.S.; project administration, M.N.K.; funding acquisition, K.N. All authors have read and agreed to the published version of the manuscript.

Funding

This research was funded by the Education Fund Management Institution (LPDP), Ministry of Finance of the Republic of Indonesia.

Acknowledgement

The authors would like to thank Universitas Pendidikan Indonesia for the academic support and research facilities provided. Gratitude is also expressed to the Education Fund Management Institution (LPDP) of the Ministry of Finance of the Republic of Indonesia for funding support during the master's study, so that this research can be carried out properly.

Conflict of interests

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

REFERENCES

Alhamlan, S., Aljasser, H., Almajed, A., Almansour, H., & Alahmad, N. (2017). A Systematic Review: Using Habits of Mind to Improve Student's thinking in Class. *Higher Education Studies*, *8*(1), 25. https://doi.org/10.5539/hes.v8n1p25

Anggereini, E., Siburian, J., & Hamidah, A. (2023). Identification of Project Based Learning and STEM PjBL Innovation Based on Socio Scientific Issues as an Effort to Improve Students' Scientific Literacy. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *11*(1), 165–177. https://doi.org/10.24815/jpsi.v10i4.26927

Arikunto, S. (2013). *Prosedur Penelitian Suatu Pendekatan Praktik. Edisi Revisi*. PT. Rineka Cipta.

Astuti, R. (2015). *Pengembangan Pembelajaran di Luar Kelas Melalui Project Based Learning dalam Meningkatkan Keterampilan Berpikir Kreatif pada Materi Penanganan Limbah*. Universitas Pendidikan Indonesia.

Broman, K., Bernholt, S., & Parchmann, I. (2018). Using model-based scaffolds to support students solving context-based chemistry problems. *International Journal of Science Education*, *40*(10), 1176–1197. https://doi.org/10.1080/09500693.2018.1470350

Costa, A., & Kallick, B. (2000). *Habits of mind: A developmental series*. Alexandria, VA: Association for Supervision and Curriculum Development.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage Publication.

Daniel, F. (2017). Kemampuan Berpikir Kritis Siswa Pada Implementasi Project Based Learning (PJBL) Berpendekatan Saintifik. *Jpmi (Jurnal Pendidikan Matematika Indonesia)*, *1*(1), 7. https://doi.org/10.26737/jpmi.v1i1.76

Durak, B., & Topçu, M. S. (2021). *Socio-Scientific Issues and Model-Based Learning* (pp. 279–297). https://doi.org/10.4018/978-1-7998-4558-4.ch010

Evcimik, S., & Oruc, C. (2023). Effects of project-based learning in moral values education. *International Online Journal of Educational Sciences*, *15*(3), 495–508.

Fitriyani, F., Atmojo, I. R. W., & Yamtinah, S. (2025). Project Based Learning Integrated with Socio Scientific Issues to Enhance Critical Thinking Skill in Elementary School. *Social, Humanities, and Educational Studies (SHES): Conference Series*, *8*(1), 625. https://doi.org/10.20961/shes.v8i1.99022

Fletcher, J. (2023). Introduction: Why Habits of Mind Matter. In *Fostering Habits of Mind in Today's Students* (pp. 1–16). Routledge.

Gafour, O. W. A., & Gafour, W. A. S. (2020). Creative thinking skills–A review article. *Journal of Education and E-Learning*, *4*(1), 44–58.

Gardner, H. E. (2011). *Frames of mind: The theory of multiple intelligences*. Basic books.

Gossard, J. M., Babits, C., Grewe, J., Taylor, C., McGonagill, D., Kofoed, M., Henderson, L., Thurston, T., Soyer, M., & Soyer, G. (2023). *Habits of Mind: Designing Courses for Student Success*.

Hayat, M. S., Rustaman, N. Y., Rahmat, A., & Redjeki, S. (2019). The improvement of prospective teachers' habits of mind during the 5E+ e inquiry learning program in horticulture course. *International Journal of Environmental and Science Education*, *14*(9), 535–545.

Hernández-Ramos, J., Pernaa, J., Cáceres-Jensen, L., & Rodríguez-Becerra, J. (2021). The Effects of Using Socio-Scientific Issues and Technology in Problem-Based Learning: A Systematic Review. *Education Sciences*, *11*(10), 640. https://doi.org/10.3390/educsci11100640

Hizqiyah, I. Y. N., Nurhadi, M., Widodo, A., & Riandi, R. (2019). Developing Habits of Mind through Web Based Learning Approach. *3rd Asian Education Symposium (AES 2018)*, 312–316.

Irwandani, A., Barata, M., Susilowati, M. F., & Villarama, N. E. (2025). *Critical*. https://doi.org/10.4815/jipi.v9i2.45948

Isnawan, M. G. (2020). *Kuasi-Eksperimen*. Nashir Al-kutub Indonesia.

Jwala, J. (2024). Gluten free Food : Fad, Friend or Foe ? *International Scientific Refereed Research Journal Available Online*. https://doi.org/10.32628/SHISRRJ

Küçükaydin, M. A. (2022). Modeling the Relationship between Preservice Elementary Teachers' Scientific Habits of Mind, Attitudes towards Socio-Scientific Issues and Scientific Literacy. *Journal of Science Learning*, *5*(2), 353–362.

Mardhatillah, Anggraini, A. E., Rahayuningsih, S., & Randy, M. Y. (2025). The Effectiveness of the Project-Based Learning Model Integrated with Digital Teaching Materials and Computational Thinking to Improve the Habits of Mind of Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 370–379. https://doi.org/10.29303/jppipa.v11i5.11155

Marzano, R. J., Pickering, D., & McTighe, J. (1993). *Assessing student outcomes: Performance assessment using the dimensions of learning model*. ERIC.

Mezirow, J. (2008). An overview on transformative learning. *Lifelong Learning*, 40–54.

Mulvia, R., Ulfa, S., & Ady, W. N. (2021). Rasch Model: Identifikasi Kemampuan Habits Of Mind Peserta Didik SMA. *JURNAL Pendidikan Dan Ilmu Fisika*, *1*(1), 15–23.

Newberry, C., McKnight, L., Sarav, M., & Pickett-Blakely, O. (2017). Going Gluten Free: the History and Nutritional Implications of Today's Most Popular Diet. In *Current Gastroenterology Reports* (Vol. 19, Issue 11). Current Medicine Group LLC 1. https://doi.org/10.1007/s11894-017-0597-2

Nolan, E., & Zeidler, D. (2025). Cultivating critical reflection through socioscientific perspectives. *Disciplinary and Interdisciplinary Science Education Research*, *7*(1), 16. https://doi.org/10.1186/s43031-025-00136-w

Ongardwanich, N., Kanjanawasee, S., & Tuipae, C. (2015). Development of 21st century skill scales as perceived by students. *Procedia-Social and Behavioral Sciences*, *191*, 737–741.

Ospankulova, E., Maxutov, S., Lathrop, R., Anuarova, L., & Balta, N. (2025). Science students' attitudes, learning, critical thinking and engagement in project-based learning. *Cogent Education*, *12*(1). https://doi.org/10.1080/2331186X.2024.2445358

Owens, D. C., Sadler, T. D., & Friedrichsen, P. (2021). Teaching Practices for Enactment of Socio-scientific Issues Instruction: an Instrumental Case Study of an Experienced Biology Teacher. *Research in Science Education*, *51*(2), 375–398. https://doi.org/10.1007/s11165-018-9799-3

Qitfirul, M., & Izza, R. (2023). Peningkatan Keterampilan Sosial Siswa melalui Project Based Learning Siswa Kelas V SD Muhammadiyah 24 Surabaya. *Pintar Harati : Jurnal Pendidikan Dan Psikologi*, *19*(1), 14–26. https://doi.org/10.36873/jph.v19i1.9407

Ratnawati, O. A., Haryani, D., Ali Hasan, Q., Artuti, E., & . P. (2024). Penerapan Pembelajaran Berbasis Proyek pada Materi Transformasi Geometri. *Jurnal Pendidikan*, *24*(2), 138–146. https://doi.org/10.52850/jpn.v24i2.12164

Reswara, T. R., Parno, Nugraheni, D., Suwasono, P., Jannah, R., & Khamis, N. (2024). Increasing scientific literacy abilities through SSI integrated PjBL-STEAM learning model on energy and simple machine topics. *Journal of Physics: Conference Series*, *2866*(1), 012107. https://doi.org/10.1088/1742-6596/2866/1/012107

Sa'adah, I. L., & Pertiwi, F. N. (2022). Pengaruh Model PjBL Berbasis Literasi Ilmiah Terhadap Peningkatan Hasil Belajar Siswa. *Jurnal Tadris IPA Indonesia*, *2*(1), 13–22. https://doi.org/10.21154/jtii.v2i1.464

Sa'ban, M. A., Tolangara, A., & Hasan, S. (2023). Pengaruh Penggunaan Model Project Based Learning (PJBL) Berpendekatan Steam Terhadap Peningkatan Hasil Belajar Kognitif Siswa Pada Kelas 7 SMP Dian Todahe Halmahera Barat. *Jurnal Bioedukasi*, *6*(1), 275–284. https://doi.org/10.33387/bioedu.v6i1.6291

Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching*, *42*(1), 112–138. https://doi.org/10.1002/tea.20042

Sri Rezekii, L., & Nugraha, T. (2024). Penggunaan Model Project Based Learning Berbasis Socio Scientific Issue untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa Kelas IV Sekolah Dasar. *Jurnal Profesi Pendidikan*, *3*(2), 53–64. https://doi.org/10.22460/jpp.v3i2.25096

Sukmadinata, N. S. (2011). *Landasan Psikologi Proses Pendidikan*. PT. Remaja Rosdakarya.

van Berge-Henegouwen, G. P., & Mulder, C. J. (1993). Pioneer in the gluten free diet: Willem-Karel Dicke 1905-1962, over 50 years of gluten free diet. *Gut*, *34*(11), 1473.

Wiyarsi, A., Prodjosantoso, A. K., & Nugraheni, A. R. E. (2021). Promoting Students' Scientific Habits of Mind and Chemical Literacy Using the Context of Socio-Scientific Issues on the Inquiry Learning. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.660495

Wu, Y., & Tsai, C. (2011). High school students' informal reasoning regarding a socio-scientific issue, with relation to scientific epistemological beliefs and cognitive structures. *International Journal of Science Education*, *33*(3), 371–400.