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The Development of Grade 3 Students' Collaboration and Teamwork Competency Using STEM Inquiry-Based Learning

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Abstract. This classroom action research aimed to study the best practices in developing collaboration and teamwork competency of 23 Grade 3 students through STEM inquiry-based learning. Data were collected from collaboration and teamwork competency assessment forms, teacher logs, and artifacts. Data were grouped according to the collaboration and teamwork competency level criteria. The research result found that students had higher collaboration and teamwork competency in all components, namely, being good members and leaders (15 students) showed level 3 in testing prototype, collaborative work process (20 students) showed level 3 in redesigning, and relationship building and conflict management (16 students) showed level 3 in redesigning. In addition, two good practices were found: integration between the design process and the key characteristics of inquiry to promote collaboration and teamwork competency and using probing questions to help students explore and collect empirical evidence to design artifacts through the design process.

Keywords: STEM inquiry-based learning; Collaboration and Teamwork Competency; STEM Education

INTRODUCTION

The first researcher is a teacher for Grade 3 students at a small school under the jurisdiction of the Bangkok Metropolitan Administration. She found that when working in groups, her students did not understand their roles and responsibilities, and some failed to seek input from their peers. As a result, the assigned tasks were often incomplete within the allocated time due to a lack of teamwork skills necessary for achieving shared goals. She tried to find ways to help her students improve collaboration and teamwork. However, in addition to teamwork challenges, the researcher observed that students struggled with conceptualizing how wind can be harnessed as an energy source. Moreover, textbooks often present wind energy in an abstract manner, lacking hands-on experiences that connect scientific concepts with tangible outcomes and real-life applications. The researchers implemented STEM inquiry-based learning to tackle the conceptual challenges in understanding wind generation and to enhance collaboration. This instructional approach integrates the essential features of scientific inquiry with the engineering design process, extending scientific explanations to solve real-world problems through STEM activities (Pimthong, 2023).

STEM inquiry-based learning integrates the core features of scientific inquiry with the design process. It extends scientific explanations toward solving real-world problems through the STEM approach (Pimthong, 2023). For instance, the study by Nilubon (2022) found that STEM inquiry-based learning enhances students' teamwork competencies by encouraging knowledge exchange among classmates and promoting collaborative activities involving analysis, discussion, questioning, and decision-making for solving situational problems. This aligns with research by Khamta et al. (2023), which showed that STEM inquiry-based learning helps students solve real-life problems by applying familiar knowledge to create products through creative problem-solving.

Furthermore, STEM education benefits primary students by fostering essential 21st-century skills (King & English, 2016). For instance, research by Samahito (2015) demonstrated that STEM education in early childhood supports development across various domains, equipping children with vital foundational skills for future learning. STEM education emphasizes classroom instruction and the promotion of STEM literacy in individuals. Through design processes, STEM learning integrates four disciplines—science, technology, engineering, and mathematics. This integration provides students with critical knowledge and skills necessary for contemporary life and the future. Among the various STEM learning approaches, STEM inquiry-based learning specifically combines the design process with key characteristics of inquiry (Pimthong, 2023; Nilubon, 2022). This study aims to identify effective practices for developing collaboration and teamwork competency in Grade 3 primary school students through STEM inquiry-based learning and to evaluate the collaboration and teamwork abilities of Grade 3 students.

RESEARCH QUESTIONS

1. What are the good practices for developing collaboration and teamwork competency in Grade 3 primary school students through STEM inquiry-based learning?
2. How does STEM inquiry-based learning enhance the collaboration and teamwork competency of Grade 3 students?

METHODOLOGY

This classroom action research was conducted using the conceptual framework of Kemmis and McTaggart (1998), which involves the development of teaching and learning from the first cycle to the new cycle to establish a solid learning management approach in each cycle (PAOR). This process consists of four steps: (1) the planning stage, (2) the implementation stage, (3) the observation stage, and (4) the reflection stage. The researchers conducted five cycles based on five lesson plans. While the PAOR framework guided the iterative improvement of teaching and learning, each cycle also explicitly integrated the five essential features of scientific inquiry namely, Engaging in scientifically oriented questions, Giving priority to evidence, Formulating explanations based on evidence, Evaluating explanations in connection with scientific knowledge, and Communicating explanations (National Research Council, 2000) integrated with the components of the design process, including Identify needs/problems, Research, Select an appropriate solution, Generate or develop the best solution, Create a prototype Test the prototype, Evaluate/Reflect and Improve (Pimthong, 2023). The researchers adapted eight activities of the STEM inquiry-based learning from Nilubon (2022), namely,

1. Identify needs/problems: Identify needs or define problems in a given context or situation. Learners participate by asking scientific questions and focusing on evidence that helps develop and evaluate explanations that answer scientific questions.
2. Research: Collect data and investigate the needs or problems studied. Learners focus on evidence that helps develop and evaluate explanations that answer scientific questions.
3. Suggest approaches: Learners generate multiple approaches to meet needs or solve problems. They evaluate their explanations by reflecting on their scientific understanding and communicating and justifying their explanations with their findings.

4. Select an appropriate solution: Generate or develop the best solution to meet needs or solve problems. Learners evaluate their explanations by reflecting on their scientific understanding.
5. Create a prototype: To meet needs or solve problems, generate a prototype of a selected solution by creating an explanation based on evidence that answers scientific questions. Learners evaluate their explanations by reflecting on their scientific understanding.
6. Test the prototype: This test determines whether the prototype of the selected solution can meet the need or solve the problem, and how, using the evidence to answer the scientific question and evaluating the explanation based on scientific understanding.
7. Evaluate/Reflect: This involves evaluating, reflecting on, or providing feedback on the prototype test to determine whether it meets the need or solves the problem, and whether it is appropriate to continue using it. It is done by creating an explanation from the evidence used to answer the scientific question, communicating the explanation, and giving reasons for it related to the discovery.
8. Improve: Improvement occurs after implementation to meet needs or solve problems as effectively as possible. The learner highlights evidence that will aid in developing and evaluating the explanation.

Participants

The participants were 23 third-grade students from a small school in Bangkok, comprising nine males and 14 females, in a classroom where the first researcher was responsible for teaching.

This research, conducted during the first author's teaching practicum, received approval from the school and parental consent. Although IRB approval was not required, the study was supervised by a mentor teacher and a university supervisor to ensure ethical standards were upheld.

Research Tools

1. There are five lesson plans (nine hours) on “Wind Generation,” which include Lesson Plan 1: Carp Flags Can Float; Lesson Plan 2: Wind Helps Carp Flags Float; Lesson Plan 3: Directional Airbags Design Sketch; Lesson Plan 4: Prototype of Directional Airbags; and Lesson Plan 5: Adjust a Little Bit to Conquer the Finish Line. The lesson plan and tools used for data collection through quality inspection by a university supervisor, a mentor teacher, and three experts.
2. Data collection tools include:

2.1 The Collaboration and Teamwork Competency Assessment Form was designed to assess students' observable behaviors during STEM inquiry-based activities. It employed a structured rubric based on OBEC's (2021) three-level competency framework: Level 1 (Beginner), Level 2 (Developing), and Level 3 (Able), namely,

- Level 1: Know their roles and responsibilities, be committed to their activities, and collaborate with others to achieve success according to agreements and regulations. Express themselves appropriately in various situations as per instructions.
- Level 2: Know and take responsibility for their roles, have confidence in completing various steps, and adhere to the instructions and rules of the team. When receiving guidance to support activities with others for success, recognize the feelings of others and respond to different situations according to the instructions.
- Level 3: Take responsibility and leverage their strengths to complete tasks. Enjoy working. Be a team member who engages in decision-making, goal setting, agreement-making, and teamwork. Demonstrate understanding to teammates with friendliness, as recommended.

The rubric score included descriptors for evaluating students' abilities to share responsibilities, contribute ideas, lead and support peers, and resolve conflicts during teamwork. Evaluations were conducted by the first researcher and confirmed with a university supervisor and a mentor teacher at the end of each cycle.

2.2 The teacher logs for the 1st researcher to record various events during teaching hours, reflections on teaching performance, and the problems and obstacles that arose in the classroom, which will be used to develop and enhance learning activities for the next time.

2.3 Student artifact assessment form and activity sheets

Data Collection

Data collection in this study employed multiple instruments to ensure comprehensive insights into students' collaboration and teamwork competency (Table 1). The researchers used teacher logs to record observations and personal learning from each teaching session to identify effective instructional design practices. Additionally, feedback from a university supervisor and a mentor teacher was gathered after each implementation to inform the best practices further. Moreover, students' artifact assessments and activity worksheets were reviewed to further prove evidence of their collaborative abilities.

Data Analysis

To address Research Question 1, the researchers employed a thematic analysis approach (Braun and Clarke, 2006). Data from teacher logs and feedback from the university supervisor and mentor teacher were read multiple times to ensure deep familiarity. Manual open coding was conducted to assign initial codes to meaningful text segments. These codes were then grouped into broader categories, from which key themes were developed. Relationships among themes were examined to identify patterns in instructional practices that supported students' collaboration and teamwork competency. Two best practices were synthesized from this process. Direct quotes were used to substantiate these themes. These external insights, combined with conversational evidence from the teacher logs (e.g., student dialogues and observations), helped to crystallize the best practices. The emerging themes were verified through peer debriefing with the mentor teacher and university supervisor to enhance trustworthiness. Their feedback was used to refine interpretations and confirm the validity of the final themes.

Table 1: Data collection and analysis.

Research Question	Instruments	Data Collection	Data Analysis
1. What are the good practices for developing collaboration and teamwork competency in Grade 3 primary school students through STEM inquiry-based learning?	Teacher Logs	The 1st researcher recorded reflections and observations after each teaching session to document what occurred and what was learned.	The teacher logs were thoroughly reviewed to identify key themes using thematic analysis.
	A university supervisor and a mentor teacher evaluation	Feedback from a university supervisor and a mentor teacher was collected after each teaching session.	Feedback was used to validate and enrich interpretations.
2. How does STEM inquiry-based learning enhance Grade 3 students' collaboration and teamwork competency?	Collaboration and teamwork competency assessment	Students completed the assessment after each session.	Data were categorized according to collaboration and teamwork competency levels defined by OBEC (2021).
	Student artifact assessments and activity worksheets	Student work and worksheets were collected and reviewed to provide evidence of their collaborative abilities.	Student work was analyzed and categorized according to collaboration and teamwork competency levels defined by OBEC (2021).

For Research Question 2, the results from student assessments and evaluations of students' work were categorized according to the collaboration and teamwork competency levels defined by the Office of the Basic Education Commission (OBEC, 2021). This allowed for a structured analysis of each student's development in teamwork skills.

RESULTS AND DISCUSSION

Findings for Research Question 1

There are two best practices, namely integrating the design process with inquiry-based learning and the using of probing questions.

Best Practice 1: Integrating Design Process with Inquiry-Based Learning

The first best practice identified was integrating the design process with key features of inquiry-based learning. This approach was found to promote students' collaboration and teamwork competency.

Lesson Plan 1: The Flying Koinobori

In the first lesson, students were introduced to airbags as directional indicators. The researcher grouped students heterogeneously and had them observe a video titled "Chasing the Koinobori Flag" to activate prior knowledge and stimulate inquiry. Students were engaged through scientific questioning and were encouraged to justify their explanations, although some were less participatory.

Students were tasked with acting as engineers to design effective directional airbags for pilots. Through tests involving various locations to make the koinobori fly, students generated explanations based on evidence and linked them to prior experiences. Due to differing experience levels, some students struggled to express their ideas, prompting the researcher to utilize diverse media, namely images, videos, and presentations, to enhance engagement. From the first lesson plan, the researchers understood that group work and inquiry-based activities fostered collaborative learning and contributed to students' prior knowledge, which aligned with the feedback from the university supervisor: *"You should demonstrate the specific student performance that reflects collaboration and teamwork during STEM inquiry-based activities."* Thus, in the next lesson, the researchers concentrated on how students participate in STEM inquiry-based activities.

Lesson Plan 2: Wind Helps the Koinobori Fly

Students participated in an inquiry activity involving video observation and an experiment on how wind is generated (Paper Spinning Snack). They were prompted with questions such as:

Researcher: What was the paper like before the candle was introduced?
Student 06: The paper didn't move.
Researcher: What happened after the candle was lit?
Student 13: The paper started spinning.
Researcher: Why do you think the paper moved?
Student 14: Because the wind made it move.

Students collaboratively summarized design specifications and demonstrated an understanding of their roles within the team. They engaged positively in various scenarios, indicating strong teamwork and shared ownership of group tasks.

Lesson Plan 3: Directional Airbag Design Sketch

Each group selected materials to design the directional airbags. Students actively answered questions and shared their opinions based on prior experience. The researcher used probing questions to stimulate creative and critical thinking, such as:

Researcher: What materials did your group choose for the directional airbag design and why?
Group 1: Material 1 because the fabric is durable.
Group 2: Material 3 because plastic is waterproof.

Students collaboratively illustrated and wrote about their design ideas. Roles were assigned within each group. This collaborative effort resulted in the successful design of products, showcasing the students' ability to work cooperatively and share responsibilities. Figure 1 shows the students' completed design sketches from the collaborative working process.

Figure 1: Worksheet 3 design sketch

Lesson Plan 4: Directional airbags Prototype

Students became more aware of their roles and responsibilities, collaborating stepwise toward a shared goal. They tested their directional airbag prototypes in different locations and documented their observations. Each team participated in the decision-making process to select the best solution and design, as illustrated in Figure 2 and the dialogue.

Figure 2: Prototypes

Researcher: Where did your prototype successfully fly?

Group 2: In front of fan settings 1 and 3 and at the front of the classroom.

Researcher: Why do you think it flew there?

Group 3: Because there was wind in the area.

Each student contributed based on their strengths, such as drawing, coloring, and writing. All group members made efforts to support one another toward a successful outcome.

Lesson Plan 5: Final Adjustments

Students brainstormed the strengths and limitations of their prototypes and then proposed design improvements. For example, as illustrated in Figure 3 and the dialogue:

Researcher: How would you improve your directional airbag?

Group 1: Use plastic, add more layers, and outline with black lines.

Researcher: Why these changes?

Group 1: Plastic is waterproof; more layers make it stronger, and black lines make it look better.

Figure 3: Redesign directional airbags of Group 1

Students engaged in reflective discussions, expressing ideas verbally and visually. They worked together to address limitations and improve their designs.

Best Practice 2: Use of Probing Questions

The second-best practice involved asking probing questions to help students gather evidence and create designs throughout the design process.

Lesson Plan 1: The Flying Koinobori

The researcher used probing questions to stimulate curiosity and assist students in exploring scientific explanations. This encouraged them to question, experiment, and connect new knowledge with prior learning. As illustrated in the following conversation:

Researcher: In which areas do your koi flags float or move?

Student 02: The balcony in front of the room and in front of the fan

Researcher: What do you believe allows these areas to make the koinobori flags float or move?

Student 04: Because there is wind

Researcher: What is wind?

Student 03: Air moves from one place to another

Researcher: Why do you think air moves from one place to another? What reasons do you believe contribute to this?

The researcher found that asking questions starting with "why" stimulated curiosity, prompting students to inquire and seek answers through their experiments or knowledge. This enabled students to connect new knowledge with what they had previously learned.

Lesson Plan 2: Wind Helps the Koinobori Fly

Before experimenting with wind generation, students were prompted with probing questions to stimulate their reasoning. Consequently, they actively gathered and evaluated evidence to support scientific claims. In the following conversation:

Researcher: What did the paper candle look like before?

Student 23: The paper stopped moving.

Researcher: What did the paper candle look like after?

Student 21: The paper spun back and forth.

Researcher: Why do you think the paper moves back and forth?

Student 14: Because the wind makes the paper spin back and forth.

The researcher sparked the students' curiosity, prompting them to ask questions that led them to seek answers through scientific explanations grounded in empirical evidence. The students collaborated, brainstormed, and navigated the design process to create the artifacts. The development of the Use of Probing Questions for promoting student learning was explicit, as shown by the mentor teacher evaluation note: "*…The preservice teacher effectively used probing and open-ended questions that revealed students' understanding.*"

Findings for research question 2

Students' collaboration and teamwork competency was assessed across three indicators: 1) Good members and leadership, 2) Collaborative work process, and 3) Relationship building and conflict management. Each indicator was rated on a three-level scale according to OBEC (2021).

The level of collaboration and teamwork competency is shown in Table 2. Most students (20) demonstrated the Able level (Level 3) in the Collaborative Work Process during the redesigning stage, indicating strength in working collaboratively in later stages of the design process. In Good Members and Leadership, 14 students reached the Able level during prototyping. Conversely, most students (14) were still at the Beginner level (Level 1) in Relationship Building and Conflict Management during the problem identification stage. Overall, the Collaborative Work Process showed the most widespread competency, while Relationship Building appears to require further development, particularly in the early stages of teamwork.

Table 2: Collaboration and Teamwork Competency (N = 23).

Design process	**Collaboration and teamwork competency**								
	Good members and leadership			**Collaborative work process**			**Relationship building and conflict management**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Identifying the need or defining the problem	-	-	-	-	-	-	14	9	0
Collecting information and researching	-	-	-	-	-	-	7	10	6
Generating ideas or alternatives	14	9	0	12	11	0	-	-	-
Choosing the best solution	0	15	8	1	8	14	-	-	-
Creating prototype	0	9	14	0	5	18	-	-	-
Testing prototype	0	8	15	0	4	19	-	-	-
Evaluating, reflecting or giving feedback	-	-	-	0	4	19	0	13	10
Redesigning	-	-	-	0	3	20	0	7	16

Details of each sub-competency are as follows:

Good members and leadership: By observing the students' group work behavior and presentations, the results indicated that students in groups 1, 2, and 3 discussed, exchanged opinions, and reached conclusions regarding the researcher's choice of materials. The students could identify whether to use cloth or plastic to create the directional airbags, as illustrated in Figure 4.

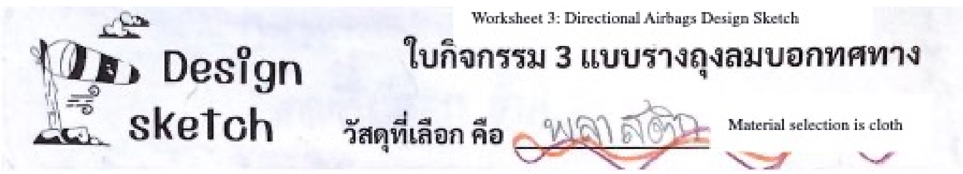

Figure 4: Activity sheet: Selection of materials used to create directional airbags for students in group 3.

However, other groups of students each chose the materials they preferred, making it impossible for them to explain the reasons behind their choices. Instead, they presented the reasons given by other groups of friends regarding the selection of materials to create the directional airbags. Later, when choosing the appropriate method, students collaborated to plan and draft the directional airbags. The researcher divided the students into groups and assigned them tasks to manage within the group. Some groups allocated their responsibilities based on their abilities and listed their names beside each member, as shown in Figure 5.

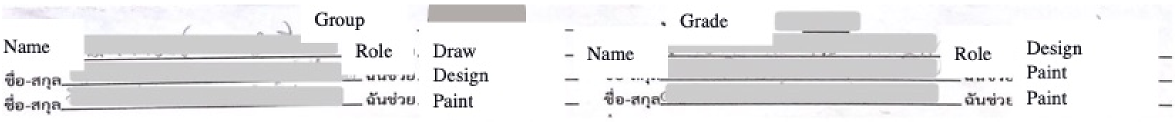

Figure 5: Division of duties in activities, draft of directional airbags

When students divide their roles, they identify their strengths and take pride in their contributions to the group. As a result, they understand different roles, assume responsibility, and assist one another in completing the work on time. Students remain accountable for their roles and cooperate effectively in building prototypes and testing the directional airbags. This is demonstrated in the following, as illustrated in Figure 6 and the dialogue.

Student 13: Does anyone want to color?
Student 19: We can color too.
Student 02: Let me be the one to cut the cloth.

Figure 6: The airbag prototype indicates the direction of students in groups 1, 2, 3, and 4.

In the testing activity, after each group of students successfully built the directional airbags, they took them to different locations to test their functionality. It was observed that the students adhered to the team's tasks and divided the work effectively.

Collaboration: Each group of students discusses and selects materials to create directional airbags. They present their reasons for choosing the materials, set goals, and maintain a group work process that aligns with those goals while taking responsibility for their assigned roles. They strive for success in their efforts and support each other as much as possible, both independently and collectively. They observe the activity of drafting the directional airbags before engaging, establishing specific design specifications, such as students' worksheets, as shown in Figure 7.

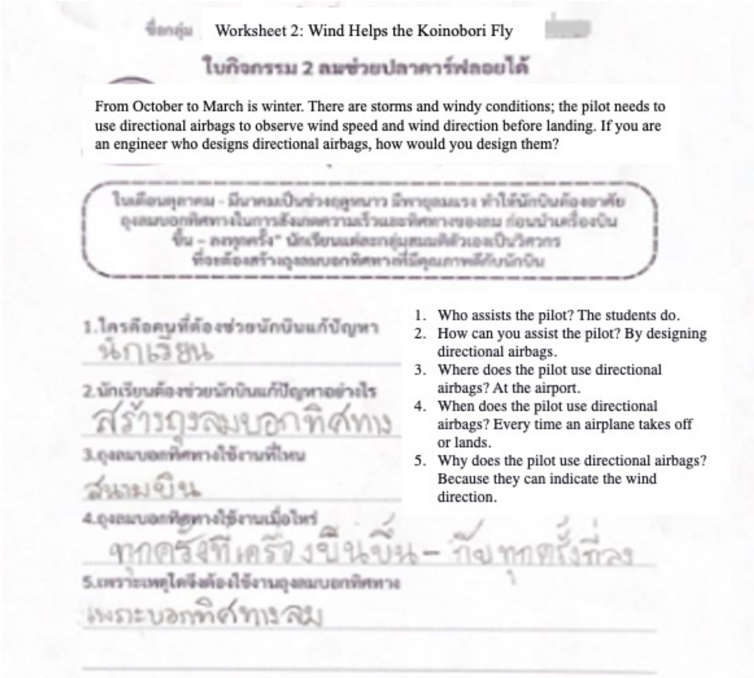

Figure 7: students' worksheets in group 1.

Later, while generating ideas and alternatives, students gathered information about the situation defined by the researcher and collectively proposed guidelines. Each group understood the team's goal and supported it by completing activities to achieve it, demonstrating their roles and responsibilities according to the steps and agreements established within the specified timeframe, as illustrated in Figure 8 and the dialogue.

Researcher: How did your team divide the tasks?

Student 03: Someone designed, drew, colored, and decorated.

Researcher: Did you complete the work within the specified time? If so, how?

Student 15: We finished on time as the teacher instructed. Researcher: How did your team complete the work within the specified time?

Student 10: We helped each other color and decorate to complete it quickly.

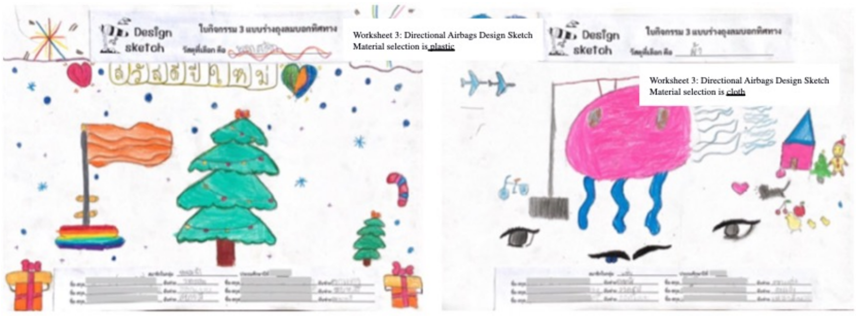

Figure 8: Airbag Direction Design for Groups 2 and 3 Students

In the testing activity, each group of students took their directional airbags to evaluate the functionality and record the test results at various locations specified by the researcher. They then jointly presented the findings of the directional airbags test. The discussion regarding the advantages and limitations of directional airbags, as well as suggestions for further development or improvement, is as follows:

Researcher: After the test, what are the advantages and limitations of your directional airbags?

Group 2 students: It breaks easily.

Group 3 students: It is not attractive.

Group 4 students: It is too heavy and does not float well.

Researcher: Given the limitations, what adjustments would you make if there were an opportunity to improve the quality of the directional airbags?

Group 4 students: We will change the materials.

Group 2 students: We will make it thicker.

The conversation demonstrates that after the students reflected on their prototypes and recognized the issues that arose, as illustrated in Figure 9, they used the worksheet to assess the advantages and limitations of directional airbags. They collaborated on improvements throughout their work until they succeeded, as depicted in Figure 10. This illustrates the systematic process that led to the completion of their project by the established goals.

Figure 9: Worksheet to evaluate/reflect on the advantages and limitations of directional airbags

Figure 10: Directional airbags improvement worksheet

Relationship Building and Conflict Management: In identifying needs and problems, students collected data on the situation specified by the researcher and the conclusions drawn from the design. They recognized the feelings of others and responded to various situations according to the guidelines provided. Following the researcher's instructions, she demonstrated positive behaviors during conflicts, such as when student 03 positively remarked, "Should we use the voting method to choose the group name?" During evaluations, reflections, or feedback sessions, each student group collaboratively reflected on their work after testing by identifying the advantages and limitations of their efforts. Students encouraged their peers to complete the activity sheets together. For instance, student 07 suggested using colored pencils during the reflection activity: "You can use colored pencils instead of magic colors, so you don't have to wait for the next color from your friends (Student 07)."

Additionally, student 22 praised their peers for motivating them in their reflection work, stating, "It's okay if you draw beautifully (Student 22). " They worked amicably, brainstorming together without arguing over resources. During improvement activities, they exhibited positive behaviors in conflicts by apologizing and forgiving one another.

After organizing all activities, it was observed that students displayed all the required components, particularly component 2, which involves the collaborative work process. Twenty students achieved level 3 competence in Component 3: Building Relationships and Conflict Management, and sixteen students demonstrated level 3 competence in Component 1: Building Relationships and Conflict Management.

CONCLUSION AND IMPLICATIONS

The results of this study suggest that STEM inquiry-based learning fosters collaboration and teamwork competencies in Grade 3 students by providing authentic contexts for skill application, peer interaction, and reflection. Throughout the iterative design process, students increasingly demonstrated competencies aligned with three key dimensions: effective participation and leadership, collaborative work processes, and relationship building, including conflict management, particularly during the prototype testing and redesign phases. The students' performance was assessed using a competency-based rubric (OBEC, 2021), which allowed for the observation of progressive abilities enactment in authentic learning contexts. These findings align with previous research (Nilubon, 2023; Khamta et al., 2023), indicating that STEM inquiry-based learning enhances students' social and collaborative engagement through real-world problem-solving and shared responsibilities. Furthermore, the observed development in students' ability to co-create, reflect, and redesign artifacts affirms the importance of integrating inquiry with design thinking in primary STEM education.

The findings are further supported by King and English (2016), who emphasized that integrating STEM concepts through iterative design provides primary students with opportunities to apply scientific and mathematical thinking in meaningful, hands-on contexts. Their research highlights the significance of the design sketch stage, collaborative group work, and opportunities for reflection and redesign in developing STEM understanding and teamwork. This study also showed these aspects as students progressed from beginner-level interaction to more proficient collaboration, particularly during the redesign phase.

Implications for classroom practice include embedding structured STEM inquiry-based learning that integrates the design process and inquiry, which scaffolds students' reasoning and promotes deeper collaboration. Teachers are encouraged to emphasize flexibility in group roles, clear communication, and guided reflection throughout the learning process. Additionally, educators might consider extending the time allocated for redesign and discussion stages to maximize the potential for integrating more complex STEM issues. Future research could explore how these approaches affect students' long-term retention of collaborative skills and STEM understanding, as well as how differentiated scaffolding might further enhance group dynamics in mixed-ability classrooms.

Implications for classroom practice include intentionally structuring STEM inquiry-based learning with a focus on group dynamics, role flexibility, and reflective dialogue. Teachers should emphasize guided questioning, equitable participation, and opportunities for peer negotiation and decision-making. Future research may investigate how sustained engagement with STEM inquiry activities supports the long-term development of collaboration competencies, particularly among learners from diverse backgrounds and abilities.

In this study, we conceptualize competency not as prior knowledge or static achievement, but as an ability cultivated and enacted through guided practice and performance-based tasks. As such, a pre-post comparison, suitable for measuring cognitive achievement, was not applied here, since competencies emerge primarily through sustained engagement rather than prior instruction. To address this concern, we have revised the Conclusion section to reflect the theoretical grounding of competency-based education. We clarified that students' increasing demonstration of collaboration and teamwork was assessed using a national competency rubric (OBEC, 2021).

Limitations of this study included its conduct within a single Grade 3 classroom during the first author's teaching practicum, which may limit the generalizability of the findings to broader contexts. Additionally, while the thematic analysis was carefully conducted and validated through peer debriefing, the interpretation of qualitative data was still largely dependent on the researcher's reflective perspective. Furthermore, collaboration and teamwork were assessed using performance-based rubrics. Although these rubrics align with national competency standards, they may not fully capture the nuanced development of interpersonal dynamics or long-term behavioral change. Future research could investigate the implementation of STEM inquiry-based learning across multiple classrooms or schools to assess its effectiveness in diverse educational contexts. Longitudinal studies would aid in examining how sustained engagement with STEM inquiry activities fosters the development and retention of collaboration and teamwork competencies over time.

REFERENCES

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.

Nilubon, C. (2023). *Developing teamwork and communication competencies of Grade 1 students through STEM learning using inquiry-based learning* (Master's thesis, Kasetsart University).

Samahito, C. (2014). Organizing learning experiences based on STEM education in early childhood education. *Journal of Education Review,* 30(2), 102–111.

Khamta, N., Phanphruaksa, K., & Latuang, T. (2023). The effects of inquiry-based learning (5E model) integrated with STEM education on Grade 6 students' learning achievement and problem-solving skills (Master's thesis, Burapha University, Chonburi).

King, D. and English, L. (2016). Engineering design in the primary school: applying STEM concepts to build an optical instrument. International Journal of Science and Education, 38(18), 2762-2794.

Pimthong, P. (2023). *STEM education instruction* (2nd ed.). Bangkok: Sunthorn Film Co., Ltd.

Saifa, Y. (2014). Concepts of STEM learning management. Unpublished instructional material, Department of Elementary Education, Faculty of Education, Chulalongkorn University.

Institute for the Promotion of Teaching Science and Technology. (2014). *STEM education: Science, technology, engineering and mathematics education* (1st ed.). Bangkok: Author.

Office of the Basic Education Commission, Ministry of Education. (2021). *Teamwork competence.* Retrieved January 12, 2025, from https://cbethailand.com/download/6640/

Office of the Education Council. (2019). *Core competency framework for students in basic education and lower primary levels (Grades 1–3).* Bangkok: Office of the Education Council.

Office of the Education Council. (2021). *Guidelines for developing students' competencies in basic education*. Bangkok: Ministry of Education.

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