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Paints of the Artist's Palette in STEAM Teaching

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Self-efficacy

Abstract

This qualitative study was an emergent phenomenological study based in the tradition of portraiture, which shares many of its features with ethnography, case study, and narrative inquiry. The purpose of this study was to identify the most engaging cooperative learning methodologies for students to actively participate in home-school learning with parents during scientific inquiry investigations and supportive strategies for teachers to employ for Science, Technology, Engineering, Art, and Mathematics (STEAM) education. The conditions identified motivated students and their parents to take ownership of the learning in which they became self-managed, self-responsible, and self-directed. Data indicated the increased success of students were the result of students participating in teacher-designed experiential, constructivist learning activities that utilized a facet of involvement strategies and provided students with authentic and socially constructive learning. Providing a guided inquiry-based learning environment also promoted student achievement and empowered students to assess their learning for developing self-responsibility, acquiring self-management skills, and raising student efficacy. As a result, students were empowered to develop scientific inquiry and literacy skills and were enabled to take control of the learning through cooperative learning that included interactive homework, collaborative inquiry-based activities, metacognitive questioning, self-assessments, and dialogue journaling.

To cite this article

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Introduction

Home-School engagement tends to weaken by the time students reach secondary school, leading to a decline in active parental involvement. The reduced engagement of parents during high school is influenced by the growing independence of adolescents and the encouragement of student self-sufficiency by parents (Catsambis & Garland, 1997; Epstein & Sheldon, 2022). The decline in home-school engagement during secondary school, driven by increased adolescent independence and parental encouragement of self-sufficiency, is particularly evident in reduced parental involvement in high school science. Parents often experience a decrease in confidence regarding their knowledge of science content, presenting a significant barrier to their participation in high school science. Consequently, cooperative parent engagement in high school science is particularly affected due to parental confidence issues related to science content and their own former experiences as science learners. Despite adolescents gaining independence, students still need ongoing guidance and support from parents as they take on greater responsibilities. Notably, areas witnessing a decline include discussions about school, homework, and parental assistance with homework (Epstein et al., 1999). Nevertheless, adolescents require the sustained guidance and support of parents as they mature and assume more responsibilities. Adolescents necessitate ongoing parental guidance and support and benefit in areas such as school-related discussions and assistance with homework.

The impact on students' interest in Science, Technology, Engineering, and Mathematics (STEM) and science courses is influenced by collaborative learning and integrated learning experiences, providing crucial support for science and STEM education (Barakos et al., 2012; Brown et al., 2011; Hebebci, 2021). Although parental involvement in student learning is more prevalent in elementary grades compared to high school, highly structured, subject-specific science and STEM learning occurs in high school as opposed to elementary school. Home engagement enhances the ability to support the development of scientific inquiry and literacy skills in STEM courses. Despite an increase in STEM-specific course enrollments during high school, parental involvement tends to decrease as students progress from elementary to high school (Epstein & Sanders, 1998; Funk & Hefferon, 2016; Hebebci, 2022).

Varying degrees of parental support and a student's home environment impact the quality of home-school relationships (Epstein & Sheldon, 2022; Shymansky et al., 2010). Creating a supportive atmosphere through social support is essential for not only facilitating learning but also empowering students in acquiring knowledge (Epstein, 1995; Mahoney et al., 2021). Supportive relationships contribute to emotional connections, the development of interpersonal skills, and the establishment of systems that aid students in achieving success (Darling-Hammond et al., 2020). To foster the development of constructivist scientific inquiry and literacy skills in students, promoting supportive and reciprocal home engagement assists in nurturing the whole child, addressing both science learning and social skills development (Dignam, 2023). Well-structured support systems contribute to the social, emotional, and academic accomplishments of all learners (Osher et al., 2018). Involving parents in activities such as homework, learning tasks, or scientific investigations rooted in inquiry promotes active learning, questioning, and the application of knowledge (Darling-Hammond et al., 2020).

Providing students and parents with experiential, constructivist learning serves as a foundation for building social capital. Additionally, the process of developing social skills and engaging in cooperative learning provides students with opportunities to develop conceptual understanding (Dewey, 1933; Piaget, 1972; Vygotsky, 1978). Experiential, constructivist learning not only fosters conceptual understanding among students but also serves as a foundation for building social capital through the development of social skills and engagement in cooperative learning. As students actively participate in constructing knowledge and self-assess progress, they develop a deep understanding of curricular objectives and outcomes, thereby reinforcing constructivist principles (Dewey, 1933; Perkins, 1999). Parental participation in homework, activities, and investigations plays a crucial role in the academic and social development of students by providing ongoing feedback, guidance, and suggestions for improvement. Therefore, involving parents in a constructivist, experiential, and interactive manner creates avenues for nurturing student ownership of science learning (Kolb, 2014; Kolb et al., 1984; Piaget, 1972; Vygotsky, 1978). Engaging parents in homework, activities, and investigations provides ongoing feedback and guidance for students' academic and social development, while also cultivating student ownership of science learning through constructivist, experiential, and interactive activities.

Students develop scientific literacy by engaging in processes that afford opportunities to experiment, apply hypothetical-deductive reasoning, and assess findings (Bowyer, 1990). Scientific literacy also serves as a predictor of student inquiry behavior, facilitating the development of literacy skills (Wen et al., 2020). Scientific literacy is a predictor for student inquiry behavior and fosters the development of critical thinking and literacy skills development. Parental involvement enhances the development of students' scientific inquiry and scientific literacy skills for a lifetime of learning (Dignam, 2023). Contemporary scientific Science, Technology, Engineering, Art, and Mathematics (STEAM) advancements positively impact society, and providing students with a guided, inquiry-based learning environment promotes student achievement for attaining relevant scientific knowledge that can be employed for a lifetime of learning (Hebebci, 2023; Wen et al., 2020).

Establishing Systems of Support

Establishing social connections plays a crucial role in fostering collaboration, which supports students developing conceptual understanding for constructing knowledge (Schieffer, 2016; Vygotsky, 1978; Woolley et al., 2015). Building social connections is critical for nurturing collaboration and communications, which assists students in developing conceptual understanding and constructing knowledge. Communication among parents, students, and teachers is central in supporting collaboration during inquiry activities (Kaufmann & Ryve, 2019). Students who are socially supported and engage in inquiry are more likely to academically achieve (Epstein & Sheldon, 2022; Woolley et al., 2015). To actively involve parents, teachers require a supportive school environment to establish a home-school relationship and build capital (Darling-Hammond, et al., 2002; Darling-Hammond et al., 2016). Experiential learning through active parental involvement enables students to develop a deeper understanding (Epstein et al., 2021; Kolb et al., 1984).

Establishing supportive relationships plays a vital role in fostering emotional connections, cultivating interpersonal skills, and establishing systems that assist students in achieving and succeeding (Darling-Hammond et al., 2020). Supportive connections between home and school promote scientific inquiry and literacy skills through constructivist, interactive learning activities and contributes to student academic achievement and enhancement of student social skills development. Fostering the development of scientific inquiry and literacy skills in students through constructivism promotes a supportive and reciprocal home-school relationship that contributes to nurturing the whole child, addressing both science learning and social skills development. Well-structured support systems contribute to the social, emotional, and academic accomplishments of all learners (Osher et al., 2018). Involving parents in interactive homework, scientific investigations, and inquiry promotes active learning, questioning, and the application of knowledge (Darling-Hammond et al., 2020).

Developing Conceptual Understanding

Providing students and parents with opportunities to engage in experiential, constructivist learning provides a foundation for fostering social capital. The process of developing social skills and engaging in cooperative learning offers students opportunities to develop conceptual understanding (Dewey, 1933; Piaget, 1972; Vygotsky, 1978). As students actively construct knowledge and assess their progress for conceptual understanding, they develop a comprehension of curricular objectives and outcomes, thereby reinforcing constructivist principles (Dewey, 1933; Perkins, 1999). Active parental involvement in homework, activities, and investigations contributes to the academic and social growth of students by providing ongoing feedback, guidance, and suggestions for improvement. Involving parents in a constructivist, experiential, and interactive manner creates avenues for students to develop ownership of science learning (Kolb, 2014; Kolb et al., 1984; Piaget, 1972; Vygotsky, 1978).

Constructivism provides teachers with processes that provide students with increased control over their learning and a platform to showcase the acquisition of knowledge. Constructivism provides students with opportunities to develop knowledge through experiential learning (Kolb, 2014; Piaget, 1972). Affording students and parents with opportunities to participate in experiential, constructivist learning creates a platform for parental involvement in high school science and home-school support. Furthermore, the process of constructing knowledge enables learners to design investigations, apply inquiry skills through collaboration, make decisions, and generate answers for understanding (Bruner, 1996). As students actively construct knowledge and self-assess their progress, they develop a deeper understanding of curricular objectives and outcomes, thereby enhancing the principles of constructivism (Dewey, 1933; Perkins, 1999).

Cooperative Engagement for Supporting Learning

Interactive Homework

As students advance from primary to secondary school, parents experience less confidence in terms of assisting with science homework; however, parental involvement continues to impact students' motivation to learn. Interactive homework is context-specific and socially constructed, directly involving parents or family members in homework activities (Epstein et al., 2021). Consistently providing students with interactive, socially supported homework fosters the development of individual interest in science learning (Renninger & Su, 2012). When parents actively participate in homework and activities, their engagement stimulates student interest, influencing self-directed and self-managed completion of homework assignments (Battle-Bailey, 2003).

Interactive homework acts as a catalyst for interactions between the home and school, as well as for parental involvement with students (Walker et al., 2004). Enabling students to actively engage parents through interactive homework, constructivist learning opportunities, self-reflections, self-assessments, and the creation of rubrics requires the establishment of a trusting relationship between the home and school that allows student, parents, and teachers to network with one another (Darling-Hammond et al., 2020; Darling-Hammond et al., 2016). Parental involvement at the high school level forms the foundation for a social network that supports student achievement and success. Social networks and support systems play a crucial role for adolescent students as they navigate through the middle and high school grade levels.

Collaborative Inquiry and Metacognitive Questioning

It is imperative for parents to be central in their child's education. For this reason, this study utilized the involvement strategy of requiring parents to engage in collaborative inquiry activities with their child and to document growth and performances by maintaining weekly entries in dialogue journals. Students and parents were provided guidance by classroom teachers for performing collaborative inquiry science learning. Teachers provided background and application of metacognitive questioning strategies with parents and students. The utilization of metacognitive questioning involves supportive conversations and opportunities for parents and students to afford explanations, elaborate on ideas, and provide reasons that foster continued learning (Gillies, 2011; Mitsea & Drigas, 2019). Parents and students employed questioning strategies with one another for home-school science learning. Parents and students engage in dialogue about science phenomena and take turns as both tutors and tutees, with the tutor beginning by asking questions that encourage the tutee to think more deeply and reflect on the topic being discussed (Gillies, 2011). Implementing metacognitive strategies boosts students' academic performance, self-confidence, and self-awareness (Mitsea & Drigas, 2019). The application of collaborative approaches through metacognitive questioning contributes to the cultivation of critical thinking and problem-solving skills in learners (Gillies, 2011; Mitsea & Drigas, 2019).

Reflective Learning

Student self-assessments have a positive impact on both student achievement and self-regulated learning. Meaningful learning activities serve as the context for self-assessments, prompting students to engage in reflections focused on improvement (Yan, 2020). While summative assessments represent final grades for specific assignments, exams, or units of study, formative assessments are continuous, providing students with opportunities for mastery through feedback and the repetition of performances. Formative assessments also play a role in influencing self-regulated learning. Science teachers should develop and utilize both formative and summative assessments, allowing students to experience various assessment modes (Artler & Spandel, 1992). Integrating student-initiated self-assessments during learning activities further enhances the effectiveness of formative assessments (Lee et al., 2020).

Dialogic Learning

Facilitating opportunities for parents and students to engage through interactive homework allows students to engage in dialogue in terms of school learning. Student-initiated conversations foster positive social interactions with parents and provide parents with insight regarding high school student learning (Epstein et al., 2021; Howard et al., 2020). Interactive homework for parents and students also creates opportunities for inquiry, self-reflection, and self-assessment. Whether in pen-and-paper or electronic form, dialogue journaling affords opportunities to document perceptions, questions, and knowledge for deeper learning. The process of recording thoughts creates communications for fostering a continuous exchange of ideas between students, parents, and teachers (Chan & Aubrey, 2021; Stillman et al., 2014). Dialogic learning contributes to the formation of a trusting relationship between students, parents and students for better supporting the social, emotional, and cognitive needs of all learners.

Research Objective

This study was conducted to identify the most engaging cooperative learning methodologies in high school science for students to actively participate in home-school learning with parents during scientific inquiry investigations. The potential significance of this research was a model of conditions and authentic strategies required to facilitate student science learning through cooperative engagement.

Research Questions

This study was conducted to determine the following research questions:

1. What are the most engaging cooperative learning strategies for use in high science for students to actively participate in home-school learning with parents during scientific inquiry investigations?
2. Which types of cooperative learning strategies were most effective in engaging both parents and students during collective, experiential inquiry?
3. How did engaging in cooperative learning affect student motivation to learn and engage in science inquiry?

Method

This research adopted a qualitative, emergent phenomenological design rooted in portraiture methodology. The study employed portraiture, incorporating elements of ethnography, case study, and narrative approaches (Lawrence-Lightfoot & Davis, 1997). By employing a qualitative, emergent phenomenological design, the research aimed to capture both objective and subjective perspectives concerning the impact of shared experiences on participants and the cognitive aspects of their social experiences (Creswell & Poth, 2018).

During interactive inquiry learning, parents, students, and teachers documented experiences in dialogue journals. The researcher analyzed attitudinal data in journal entries to ascertain parental and student perceptions regarding student growth, participation, and ownership of the learning. Attitudinal data from journal entries were cross-referenced with surveys, questionnaires, and interviews to ensure comprehensive and reliable insights. Students engaged in self-assessments, which served as the primary instruments for gathering data regarding cooperative interactions and their impact on student learning and perceptions by parents and students.

In addition, students completed interactive homework and science inquiry activities with parents. Students and parents created criteria after inquiry activities that related what students and parents believed were the most important attributes of the scientific inquiry learning that occurred. Teachers engaged students in the classroom to create rubrics students constructed. Parents and students were also involved in creating exam questions to measure student learning. Students completed reflective, self-assessments of the learning to memorialize what was learned, aspects of learning that impacted student confidence, and what students would change regarding performances.

Results

Data were analyzed for themes and descriptive statistics were used to identify patterns and relationships amongst themes. Student descriptive statistics (Tables 1 and 2) and parent descriptive statistics (Tables 3 and 4) also served sources for the construction of univariate and multivariate tabular and graphic interpretations of inter-rater codification to visually identify themes for identifying relationships and triangulating findings. These data indicate that parents provided a great deal of support during home-school activities. Parents and students were actively involved during this research project in corresponding with one another through their dialogue journals and maintained open lines of communication. One parent stated in a dialogue journal entry after he and his child determined the scientific names of the leaf species they collected and stated, "I feel like I'm in biology again but this time I'm actually getting something out of it." Attitudinal data indicated that the dialogue journals provided a forum for communicative opportunities to take place and fostered the ownership of learning in students and parents.

Table 1. Student interview results regarding parents, journals, and motivation

Question That Elicited a Descriptive Statistic Response	Percentage Agreeing
Students were looking forward to working with parents	20%
Students were not looking forward to working with parents	60%
Students did not have an opinion on working with parents	20%
Students responded experiences did not impact/change motivation	25%
Students felt an increase in motivation after engaging in inquiry	75%
Dialogue journal entries positively influenced learning	85%
Dialogue journals were helpful in communicating with parents	70%
Dialogue journals were helpful in taking responsibility for learning	80%
Self-reflections positively affected motivation to achieve	75%
Self-reflections improved ability to make adjustments and perform	80%
Motivation to learn increased after engaging in inquiry activity	90%

Table 2. Student interview results regarding self-assessments and confidence

Question That Elicited a Descriptive Statistic Response	Percentage Agreeing
The student-constructed exams related to inquiry…	
Motivated students to learn science	30%
Was helpful because it made students feel important	35%
Improved learning	25%
Other	10%
Students felt that constructing a rubric….	
Motivated students to succeed	75%
Provided students with direction	85%
Helped students better self-assess	70%
Was fun to do/other	80%
The most helpful strategies that impacted student success were…	
Self-assessing	30%
Using the student-constructed rubric	30%
Maintaining the dialogue journals	25%
Constructing and choosing the questions for exams	10%
Felt more confident to engage in scientific inquiry activities	85%

An objective of this study was to determine if students would develop self-responsibility and take ownership of the learning. As a result of maintaining self-reflections and formative assessments in dialogue journals, 85.0 % of students who volunteered to be interviewed responded that they were able to take control and responsibility of the learning. During an interview with a parent regarding her experiences in corresponding with her child through the dialogue journals, the parent responded that she "had never done anything like this before" and this strategy "made it easier to talk about all types of stuff" with her child. Another parent said that she felt like she knew her daughter "better" and as a result of the dialogue journals, the parent "watched [her child] learn and I learned with her." The dialogue journals helped parents and students better communicate. These parents indicated that they felt they were able to gauge their children's learning and observe them flourish. The reflective entries in journals enabled parents to *watch students learn* and to reflect on student abilities, motivation, and ownership of the learning. Tables 3 and 4 on the following pages illustrate parents' feelings and perceptions on the effectiveness of the dialogue journals and the most effective strategies utilized during this study.

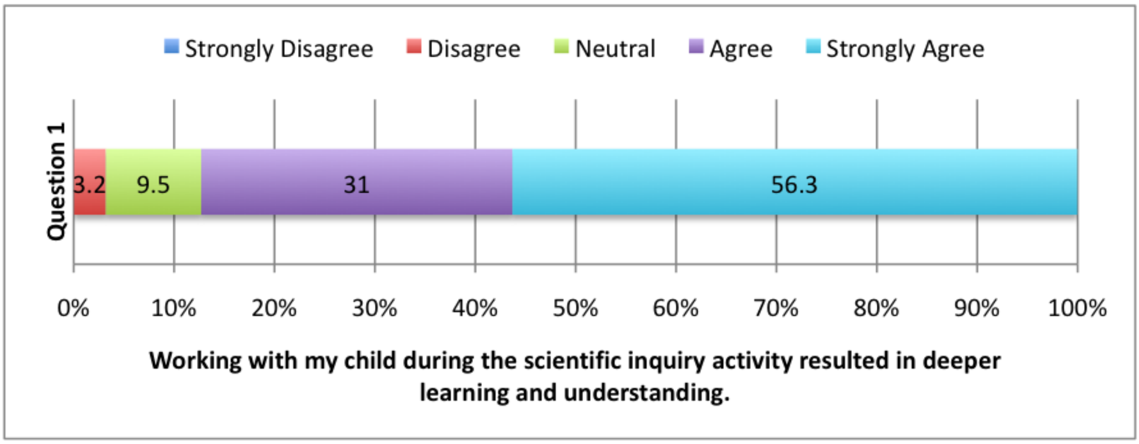
Table 3. Parent interview results regarding journals and student confidence

Question That Elicited a Descriptive Statistic Response	Percentage Agreeing
Dialogue journals were helpful in communicating with students	85%
Journals, self-reflections, and self-evaluations motivated students	80%
Experiences in corresponding in dialogue journals….	
It was a positive experience	85%
It was helpful for improving communications	85%
Facilitated student commitments and responsibilities	75%
Students learning habits improved	85%
Students' confidence increased	90%
Students' confidence remained the same	10%

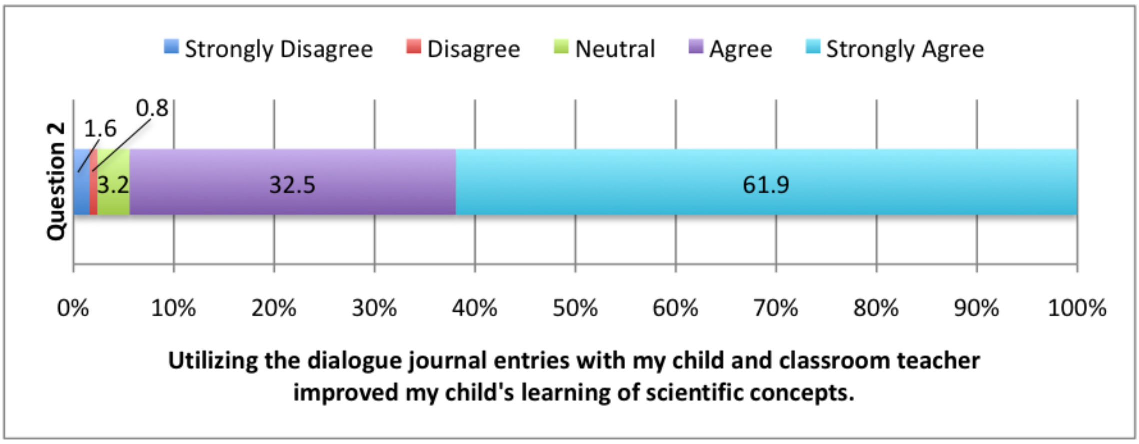
Table 4. Parent interview results regarding journals and student confidence

Question That Elicited a Descriptive Statistic Response	Percentage Agreeing
Parents were looking forward to working with their child	80%
Parents were apprehensive about working with their child	20%
A greater amount of collaborative involvement should be used	90%
Most helpful strategy to take control of the learning was….	
Self-assessing with parents	40%
Communicating in the dialogue journals	35%
The student-constructed rubric that parents and students used	15%
Designing the exam questions	10%

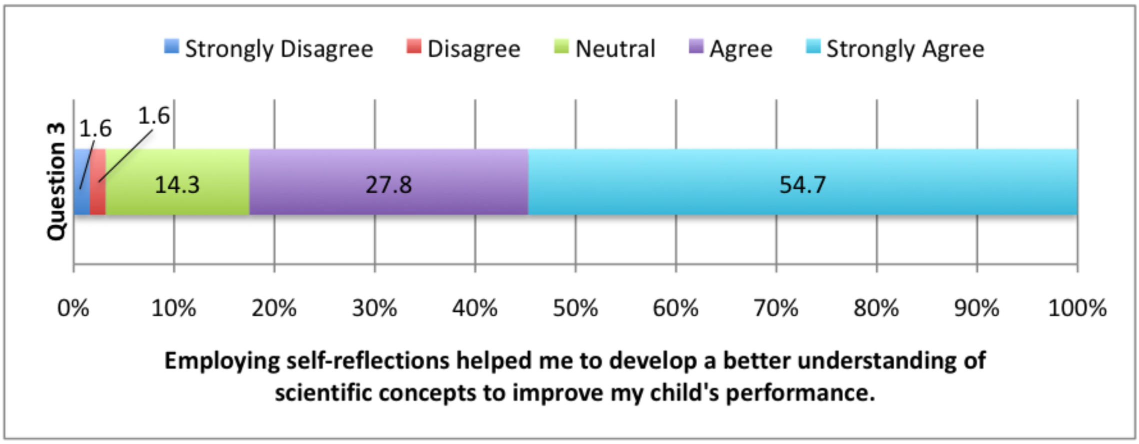
Parents noted in interviews strategies that helped students take ownership of the learning were the construction of the class rubric and examination by the students, (Figure 1). Students constructed a class rubric to gauge and assess their learning and an examination to measure their understanding of the key concepts. The construction of the class rubric and examination by the students provided students with a framework to make self-assessments based on their understanding, proficiency, and fluency of the key concepts. Students gauged their learning and made self-evaluations of their progress and adjustments to deliver a high-quality performance based on the criteria they developed. A student stated in her journal that constructing the rubric helped her performance in this activity because she knew "what characteristics separated a great project from an OK project."



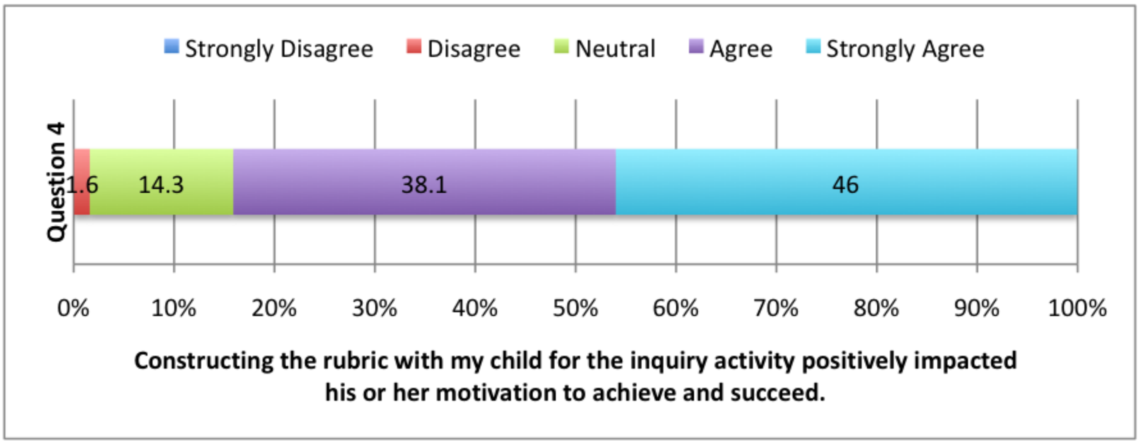
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 1
3.2
9.5
31
56.3
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Working with my child during the scientific inquiry activity resulted in deeper learning and understanding.



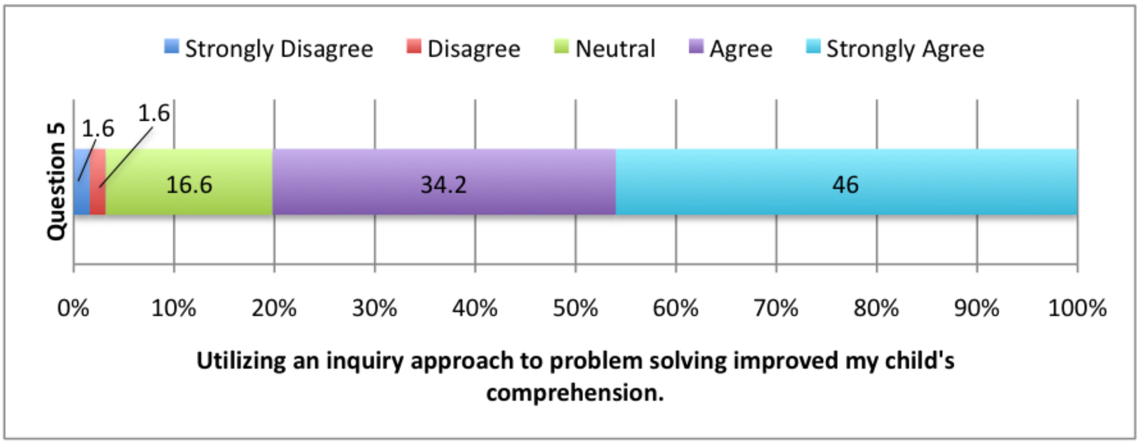
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 2
1.6
0.8
3.2
32.5
61.9
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Utilizing the dialogue journal entries with my child and classroom teacher improved my child's learning of scientific concepts.

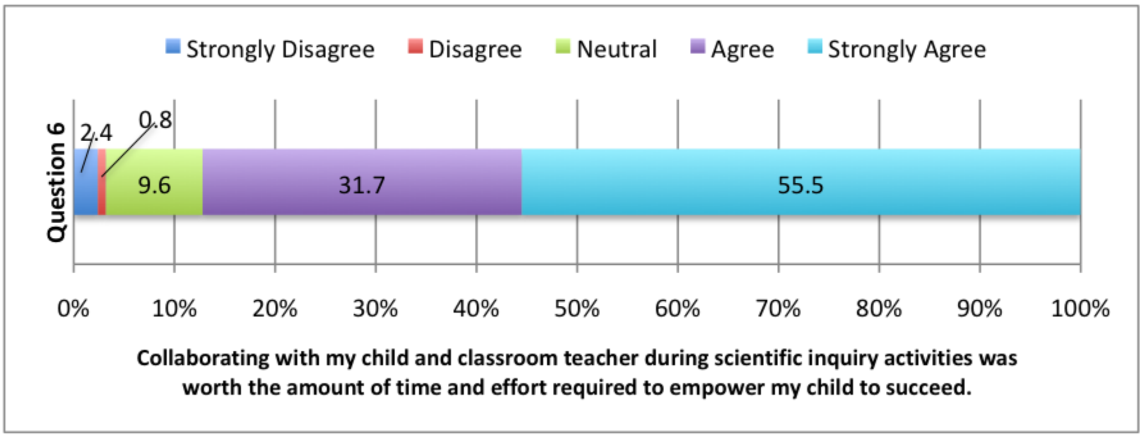


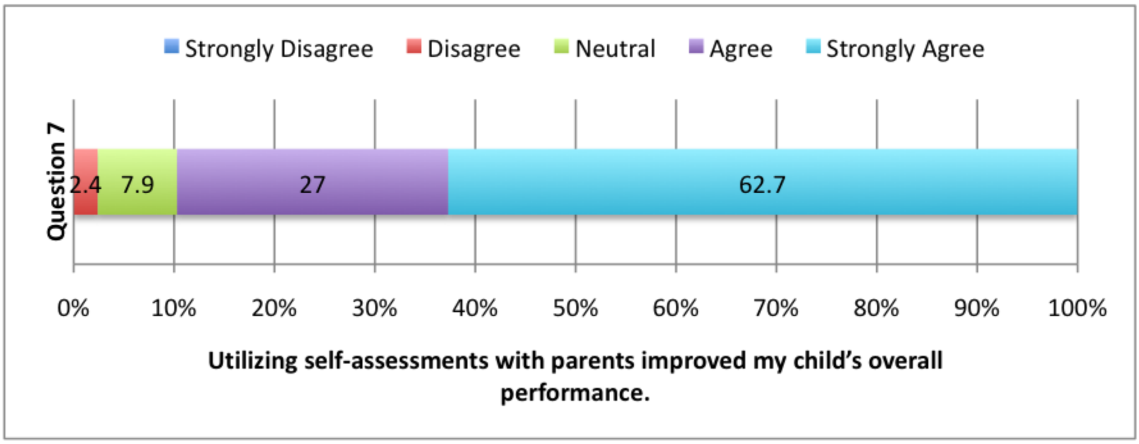
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 3
1.6
1.6
14.3
27.8
54.7
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Employing self-reflections helped me to develop a better understanding of scientific concepts to improve my child's performance.

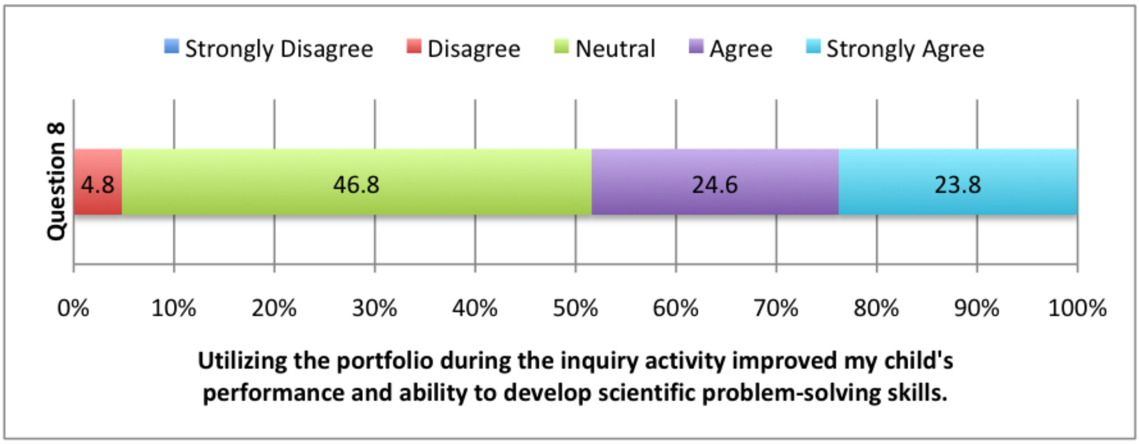


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 4
1.6
14.3
38.1
46
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Constructing the rubric with my child for the inquiry activity positively impacted his or her motivation to achieve and succeed.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 5
1.6
1.6
16.6
34.2
46
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Utilizing an inquiry approach to problem solving improved my child's comprehension.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 6
2.4
0.8
9.6
31.7
55.5
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Collaborating with my child and classroom teacher during scientific inquiry activities was worth the amount of time and effort required to empower my child to succeed.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 7
2.4
7.9
27
62.7
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Utilizing self-assessments with parents improved my child's overall performance.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 8
4.8
46.8
24.6
23.8
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Utilizing the portfolio during the inquiry activity improved my child's performance and ability to develop scientific problem-solving skills.

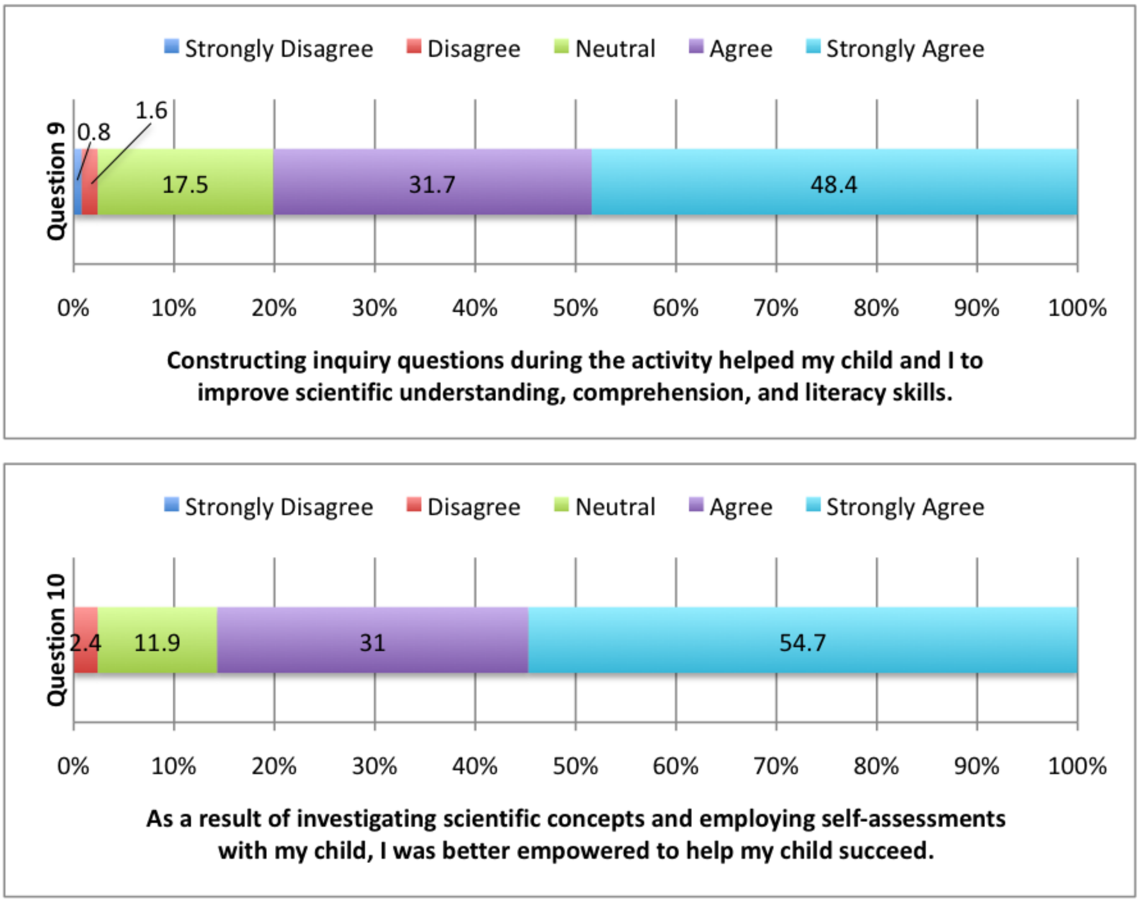
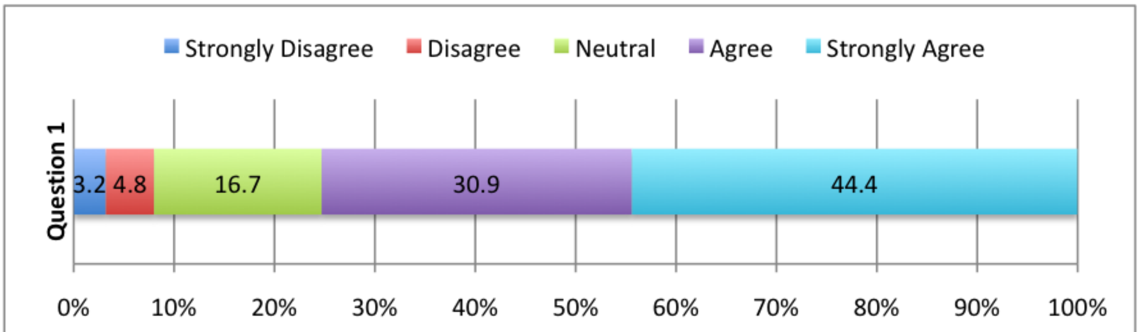
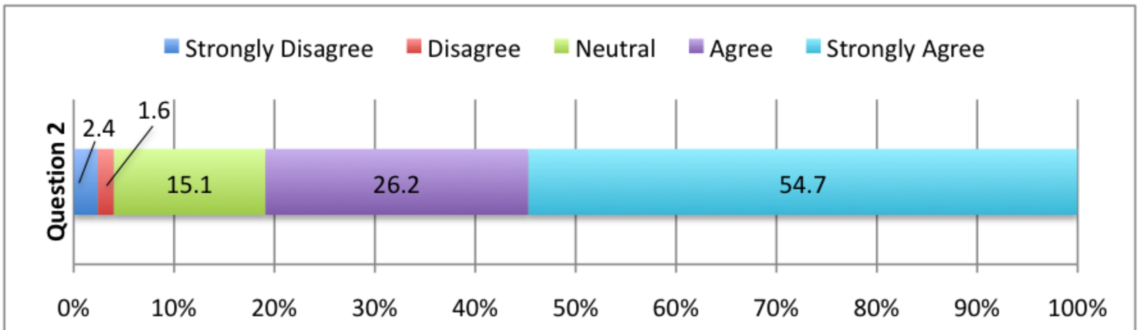


Figure 1. Parent interview responses

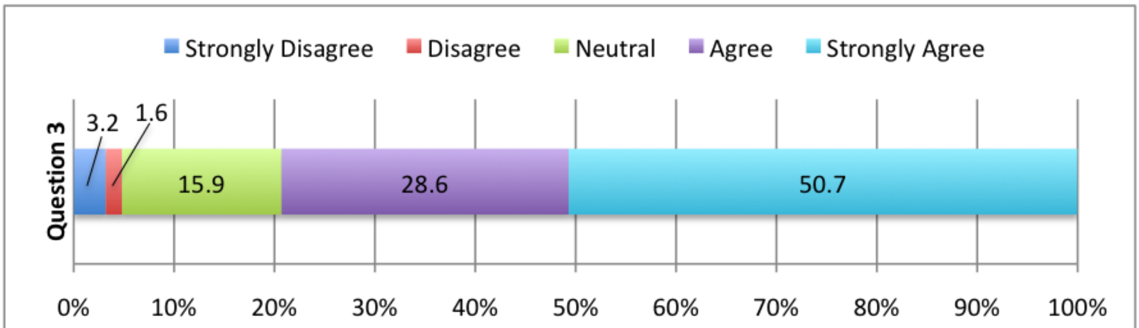
Students' interview responses noted how students perceived an ownership of the learning through construction of the class examination (Figure 2). Prior to the actual administration of exams during the unit of study, students determined what attributes exemplified a knowledge base of the key concepts and learning goals of inquiry. When students were asked during interviews which strategy they found most helpful, their responses were divided in half. When interviewed, 30.0 % of the students stated that constructing a rubric was the most helpful strategy students utilized. In addition, an equal percentage of students (30.0%) responded that the strategy of making self-evaluations and self-assessments was the most helpful because it aided students in making much needed adjustments to improve individual performances.



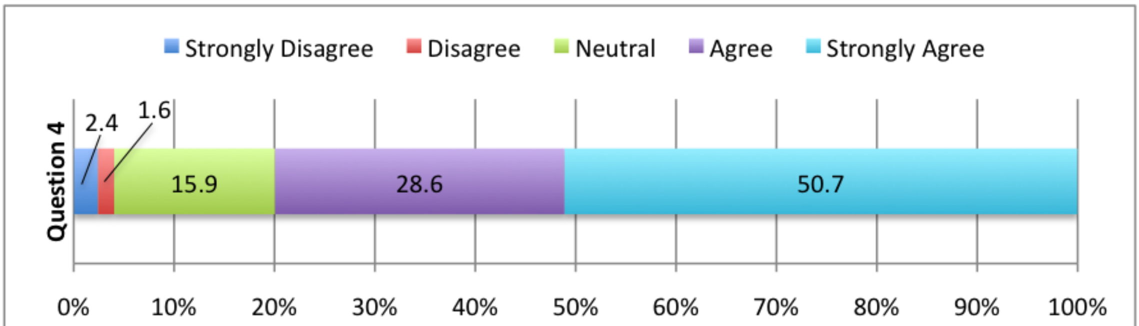
Working with my parent(s) during the scientific inquiry activity resulted in deeper learning and understanding.



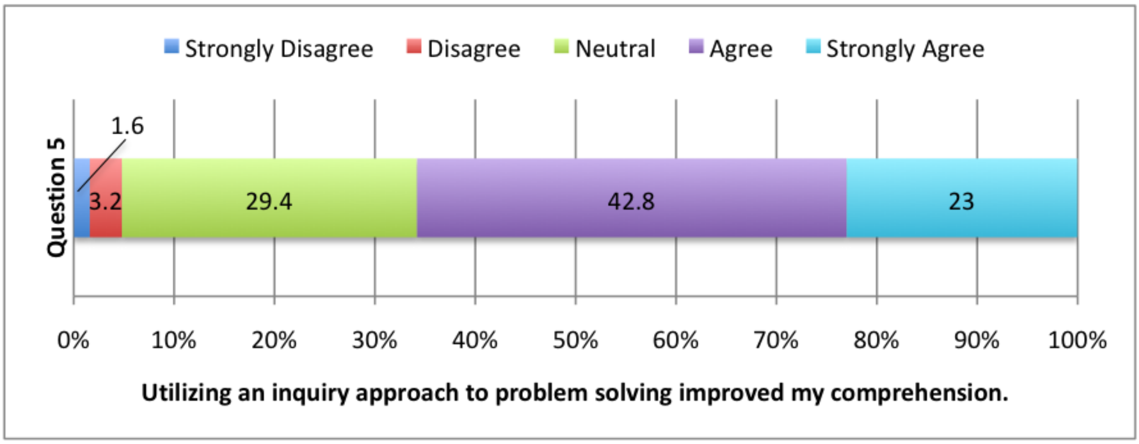
Utilizing the dialogue journal entries with my parent(s) and classroom teacher improved my child's learning of scientific concepts.

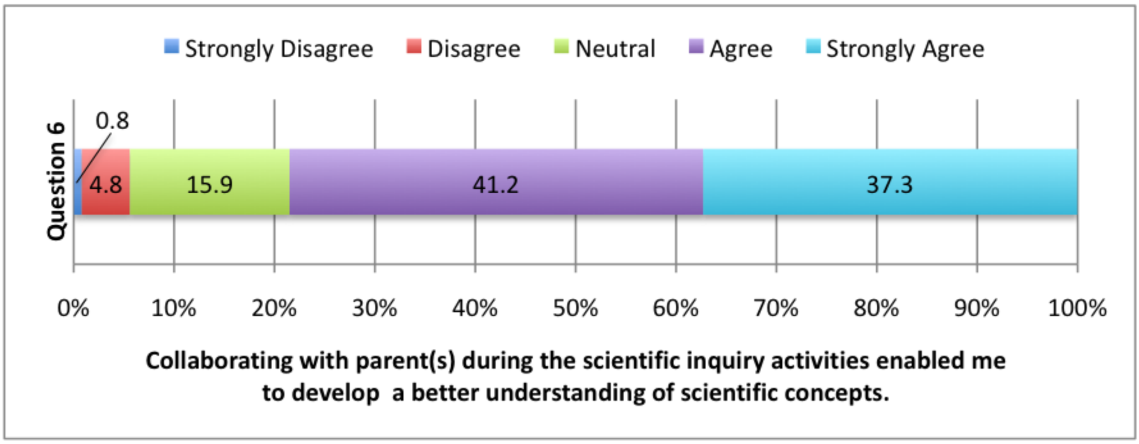


Employing self-reflections helped me to develop a better understanding of scientific concepts to improve my performance.



Constructing the rubric with my parent(s) for the inquiry activity positively impacted my motivation to achieve and succeed.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 5
1.6
3.2
29.4
42.8
23
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Utilizing an inquiry approach to problem solving improved my comprehension.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 6
0.8
4.8
15.9
41.2
37.3
0%
10%
20%
30%
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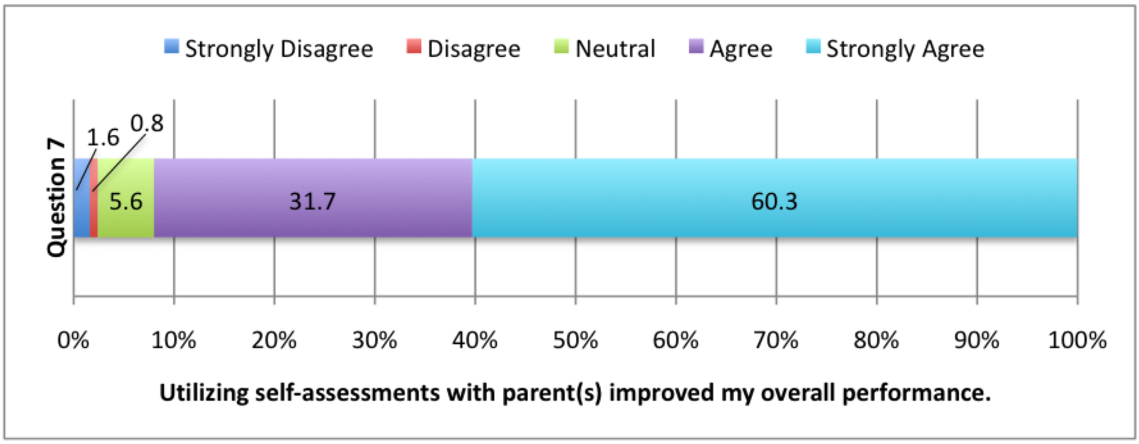
60%
70%
80%
90%
100%
Collaborating with parent(s) during the scientific inquiry activities enabled me to develop a better understanding of scientific concepts.


Strongly Disagree
Disagree
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Agree
Strongly Agree
Question 7
1.6
0.8
5.6
31.7
60.3
0%
10%
20%
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40%
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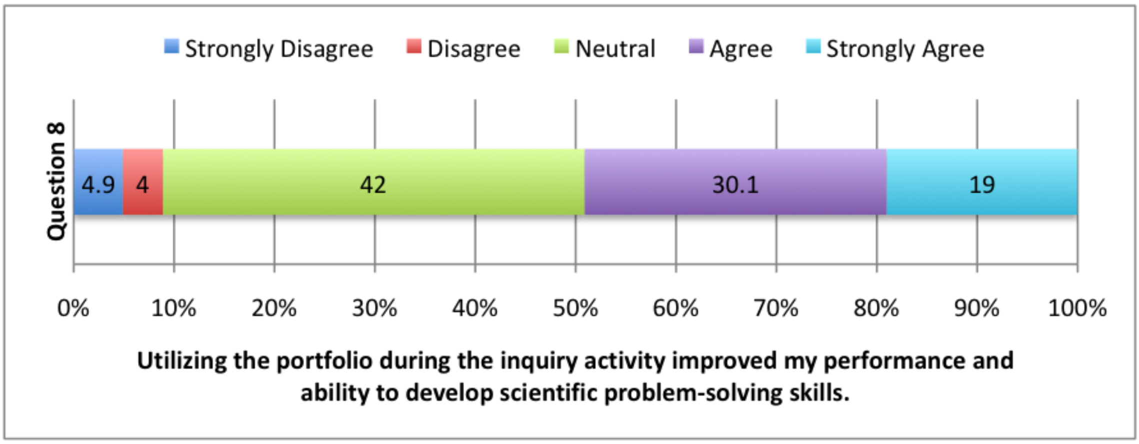
60%
70%
80%
90%
100%
Utilizing self-assessments with parent(s) improved my overall performance.


Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
Question 8
4.9
4
42
30.1
19
0%
10%
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60%
70%
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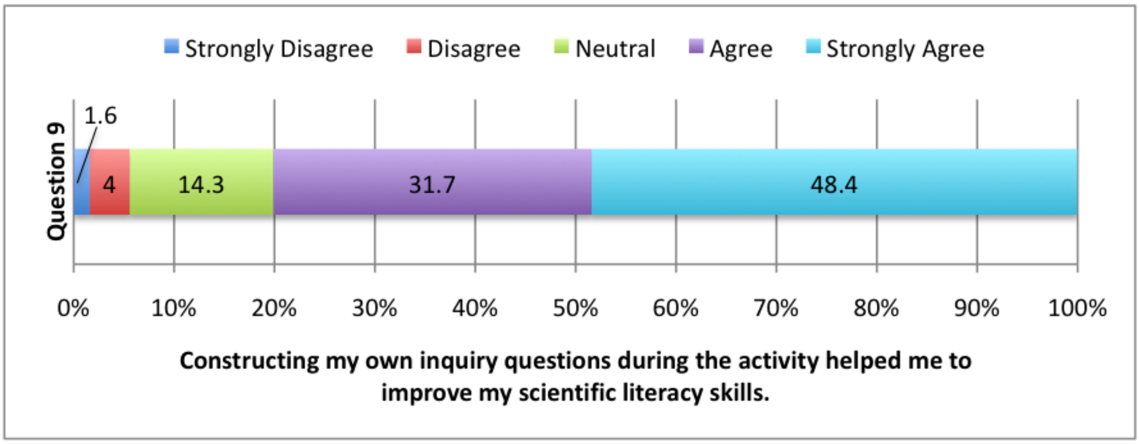
100%
Utilizing the portfolio during the inquiry activity improved my performance and ability to develop scientific problem-solving skills.



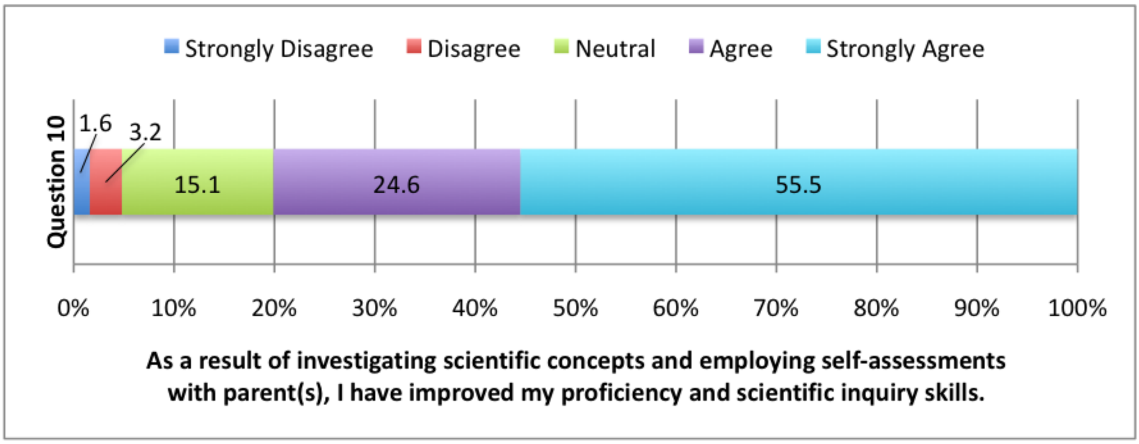


Figure 2. Student interview responses

Attitudinal data revealed dialogue journal entries created opportunities to establish positive, pro-social relationships between parents and students. Perceptions from parents and students indicated that dialogue journals were instrumental in promoting constructive communication among parents, students, and teachers. Journals facilitated meaningful dialogue, allowing students to engage in self-reflections and self-assessments for improvement and achievement. Through this process, students gained an understanding of the modifications needed to succeed, informing parents and teachers about their knowledge and comprehension. A teacher's journal entry highlighted, "When students are provided opportunities to reflect on their progress and performances, they determine the changes and adjustments they need to make in order to be more successful."

Discussion

Dialogue journal entries provided a wealth of self-reflective discourse in which students initiated communications, followed by parents, and finally teachers, who acknowledged student-parent discourse and occasionally provided encouragement. Teachers on the other hand maintained private journals to memorialize thoughts and perceptions at random for review by the researcher at the conclusion of the study. Attitudinal data provided insight regarding teacher, parent, and student thoughts and their lived experiences highlighting social networking, social capital building, and influences on STEAM learning. The identified conditions prompted students and parents to take ownership of learning, fostering self-management, self-responsibility, and self-direction among learners. Experiential, constructivist learning activities promoted authentic and socially constructive learning experiences and empowered students to assess their own learning.

Conclusion

This study sought to determine (1) the most engaging cooperative learning strategies for use in high school STEAM learning with parents during scientific inquiry investigations, (2) the types of cooperative learning strategies that were most effective in engaging both parents and students, and (3) the effect of students engaging in cooperative learning effect during science inquiry. Data indicated the increased success of students were the result of students participating in constructivist learning activities that utilized a facet of involvement strategies and provided students with authentic and socially constructive learning. The ability of students to assess their learning assisted students in developing self-responsibility, acquiring self-management skills, and increasing student efficacy. As a result, students were empowered to engage in science learning and were enabled to take control of the learning through cooperative learning that included strategies such as interactive homework, collaborative inquiry-based activities, metacognitive questioning, self-assessments, and dialogue journaling.

The involvement of parents in discussions through dialogue journals, inquiry-based assignments, and interactive homework assignments resulted in improved student academic success. Cooperative learning opportunities facilitated student acquisition of scientific inquiry and literacy skills as a result of collaborating with parents and questioning and answering through the process of connecting through inquiry. Inquiry was a student-centered conceptual design that allowed parents to provide guidance and enabled students to control the learning during student-centered inquiry activities. Interactive parental involvement promoted an exchange of ideas and encouraged students to defend their ideas to support their positions through dialogue. As a result of these processes, parents were actively involved in the assessment and reassessment of student beliefs and understandings.

When parents guide students through activities, students are provided opportunities to reflect on what was learned and develop a deeper understanding of science concepts. Guiding students through the learning in a cooperative learning environment enabled students to develop an understanding of the concepts that they worked out themselves as a cooperative parent-student team. Constructivist learning during inquiry-based activities with parents provided a supportive, cooperative network that improved student science learning. Constructivism empowered students to develop their own questions about scientific concepts that created dialogue in the forms of metacognitive questioning. Metacognitive questioning enabled both parents and students to become metacognitive guides for one another and empowered students to take control of the learning.

The involvement strategies parents and students employed motivated parents and students to take ownership of the learning. As a result, parental and student efficacy was increased and instructional practices were improved. Data indicated the increased success of students in this study were the result of students participating in an activity that utilized a facet of involvement strategies and provided students with authentic and socially constructive learning opportunities. Students believed their experiences were genuine and relevant. Many students believed they “felt like real scientists" and the learning was memorable and meaningful.

Recommendations

Data indicated cooperative learning via experiential learning, constructivism, interactive homework, collaborative inquiry-based activities, metacognitive questioning strategies, and dialogue journaling were highly effective in supporting student growth and achievement. Parent involvement in science learning activities at the secondary level through specific cooperative learning strategies resulted in students’ acquisition of scientific learning and parent and student efficacy. Data also indicated teachers increased their willingness to elicit parent involvement to support inquiry activities. Students believed their willingness to collaborate with parents increased during inquiry-based activity learning. Teachers also believed their professional efficacy and ability to form partnerships with parents increased as a result of employing proactive and interactive parent involvement strategies.

Students were an integral component of the learning and controlled the knowledge ascertained. Parents actively participated and communicated with students during the investigation and provided interminable support. It is recommended that students engage in experiential, cooperative learning either with other students in class or externally with parents to facilitate student science learning. Students gained knowledge as a result of utilizing metacognitive questioning strategies to derive solutions and construct meaning. Students made self-reflections and self-assessments to redirect their efforts and improve performances. The ability of students to assess their learning in concert with the other involvement strategies should be employed to support students developing self-responsibility, acquiring self-management skills, and for raising student efficacy.

Students believed they were empowered to develop scientific inquiry and literacy skills and were enabled to take control of the learning. Students were able to use these skills in developing criteria in constructing a rubric and to develop exam questions to test their understanding of the key concepts and learning goals. A primary plan-of-action should be made to continue utilizing these strategies in STEAM classrooms to enable students to develop skills they can use throughout a lifetime of learning.

Teaching and learning theories should be considered in enlisting parent involvement and providing all students with multiple opportunities to learn the content and assess performances. For example, when parents are involved in inquiry activities with students, self-assessments and self-reflections should be encouraged to ensure students are provided multiple opportunities to demonstrate learning. Problem-based learning theory engages students in solving authentic science core subject or STEM case problems with parents through cooperation. Utilizing this theory may provide parents and students with both the social context and inquiry-based learning opportunity to reflect upon learning. The guidance, feedback, and authentic learning opportunities parents provide students during experiential, inquiry-based, constructivist problem solving facilitates a desire to learn and achieve.

Student assessments were devised to enable students to demonstrate knowledge that was learned. To combat the limited assessment experienced by most science students, teachers should create and employ assessments that are both formative and summative to evaluate student performance. Concept maps, portfolios, rubrics, and student self-assessments should be considered to better assess student growth. Students must be provided opportunities to construct knowledge through authentic, meaningful, educational experiences to achieve and succeed.

A recommended action should also include involving all students' parents in corresponding on a continuous basis in dialogue journals. Although dialogue journaling is time consuming, with the advent of a variety of electronic media platforms available for students, parents, and teachers, utilizing these tools may provide regular, positive communications for creating a positive, supportive relationship for all learners.

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