Brushstrokes of Thoughts and Perceptions in Science Learning

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Article Info	Abstract
	According to J. Epstein's (2022) Theory of Overlapping Spheres of Influence, three influential spheres are symbiotic and overlap: school, family, and community. Social networks and social capital are rendered through the implementation of cooperative, interactive partnerships among families, educators, and communities when they are centered on children's growth and development. Additionally, L. S. Vygotsky's (1978) Theory of Cognitive Development asserts social interaction between learners is central to learners developing understanding, as concepts are first formed on the social level followed by the individual level. This qualitative research study examined the thoughts, perceptions, and acuities of students, parents, and teachers as they partnered during high school science inquiry investigations and their perceptions regarding social interactions and cognition. This qualitative phenomenological study examined the development of social skills in students and influencing factors in motivating students to take ownership of the learning. This study also examined the assimilation and accommodation of cognition in study participants' perspectives as they engaged in scientific, experiential learning with implications for Science, Technology, Engineering, Art, and Mathematics (STEAM) teaching and learning.

Introduction

Although home-school relationships decline at the secondary level, which often inhibits active parent involvement, opportunities to forge social networks and build social capital between the home and school still exist (Epstein & Sheldon, 2022). The decline in social networking is influenced by students beginning to establish independence as adolescents and parents enabling student independence (Epstein & Connors, 1994).

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Despite science being adversely impacted in terms of high school home-school engagement for social networking and building social capital, strategies exist to elicit opportunities for students, parents, and teachers to form authentic social bonds (Epstein et al., 1999). Adolescents need the continued guidance and support of parents as they mature and assume increased responsibilities. As a countermeasure to this phenomenon and implications for high school science, teachers at the secondary level can foster social capital by actively engaging parents in learning activities (Dignam, 2023b; Epstein et al., 1999). Not only is the engagement of students through partnering beneficial for cognitive growth, it is superseded and influenced by the social interactions of students and their perceptions of learning.

When schools create conditions for developing a community of practice via participatory, reciprocal parent-teacher-student relationships, they forge the establishment of a communal learning system. Many schools promote the idea of partnering with parents and families to establish communal goals. However, teaching and learning largely occurs in isolation from the home and takes place within the school. Consequently, the home and school share common social goals but operate independently of one another. Conversely, when the home and school actualize their relationship as a mutually supportive social network, they form linkages via a partnership of common interests and shared engagement for cognition (Darling-Hammond et al., 2020; Vygotsky, 1978).

Supportive Literature

Mutualistic home-school partnerships are those that move beyond passive school engagement and bounded invites for parents with occasional communications sent home by teachers and towards a linked relationship of working together to actively engage and support social networks. Home-school partnerships that are cooperative and interactive forge relationships that are mutualistic, reciprocal, and provide substrate for social capital. With social capital, learners develop social skills to further develop understanding for cognition via social partnerships and finally as individuals (Vygotsky, 1978).

The connection between homes and schools tends to weaken at the secondary school level, leading to a reduction in active parent involvement. The decrease in parental engagement during high school is influenced by the emerging independence of adolescents and the encouragement of self-sufficiency by parents (Catsambis & Garland, 1997; Epstein & Sheldon, 2022). Additionally, parents often feel a decrease in confidence regarding their own knowledge of science content, posing a significant obstacle to their involvement in high school science education. Despite adolescents developing independence, students still require ongoing guidance and support from parents as they take on increased responsibilities. Notably, areas experiencing a decline include discussions about school, homework, and parental assistance with homework (Epstein et al., 1999).

Among the most influential factors affecting student learning are the student's home environment and varying levels of parental support (Epstein & Sheldon, 2022; Shymansky et al., 2010). Building a supportive environment through social support is crucial for fostering not only learning but also empowering students to acquire knowledge (Epstein, 1995; Mahoney et al., 2021). Supportive relationships contribute to emotional connections, the development of interpersonal skills, and the establishment of systems that help students achieve success (Darling-Hammond et al., 2020). To promote the development of constructivist scientific inquiry and literacy skills in students, encouraging supportive and reciprocal home engagement aids in nurturing the whole child, addressing both science learning and social skills development. Well-designed support systems contribute to the social, emotional, and academic achievements of all learners (Osher et al., 2018). Involving parents in activities such as homework, learning tasks, or scientific investigations grounded in inquiry stimulates active learning, questioning, and the application of knowledge (Darling-Hammond et al., 2020).

The influence of parental involvement on student perceptions and motivation to learn remains significant, whether the student is in primary school or at the secondary level. Creating opportunities for parents and students to engage in scientific, interactive inquiry promotes students taking the lead in discussions about their school learning (Dignam, 2023a). These constructive, student-led conversations foster pro-social interactions and result in positive sentiments among parents, providing valuable insights into high school student learning (Epstein et al., 2021; Howard et al., 2020).

Influences on Cognition

Evidence suggests that factors such as family influence and students' personal interests outside the traditional school-learning setting significantly influence student interest in core science areas and Science, Technology, Engineering, and Mathematics (STEM) education (Funk & Hefferon, 2016; Shymansky et al., 2010). Both STEM and STEAM (Science, Technology, Engineering, Art, and Mathematics) learning play a vital role in fostering the development of critical thinking skills, which are essential life skills, and crucial for lifelong learning (Ross, 2011; Hebebci, 2022; 2023). Furthermore, collaborative and integrated learning experiences have a substantial impact on students' interests in science and STEM, playing a key role in providing supportive and enriching science and STEM learning experiences for students (Barakos et al., 2012).

Affording students and parents opportunities to participate in experiential, constructivist learning serves as a platform for building social capital. Moreover, the process of forging social skills and cooperative learning provides students with opportunities for developing conceptual understanding (Dewey, 1933; Piaget, 1972; Vygotsky, 1978). As students engage in constructing knowledge and self-assessing their progress, they cultivate

a profound understanding of curricular objectives and outcomes, thereby enhancing constructivist principles (Dewey, 1933; Perkins, 1999). Parental involvement in homework, activities, and investigations contributes to the academic and social development of students by offering continuous feedback, guidance, and suggestions for improvement. Hence, constructivist, experiential, interactive parental involvement creates opportunities for fostering student ownership of science learning (Kolb, 2014; Kolb et al., 1984; Piaget, 1972; Vygotsky, 1978).

Professional Erudition

Teachers are better positioned to support student learning when they engage in targeted professional growth (Kirner & Lebrun-Griffin, 2013). The researcher is a former high school science educator with approximately ten years of classroom experience and seventeen additional years of educational leadership experience as an administrator and in leading schools as a principal and district superintendent. The researcher has employed the term professional erudition during his tenure in leading schools and communities as a principal and superintendent, and with his students in higher education seeking educational degree attainment and licensure. Professional erudition is a form of professional practice-building that includes aspects of targeted professional development for episode growth as well as professional development for periodic growth through meaningful onsite underpinning (Dignam, 2023a).

As noted in the research design portion of the methods section of this article, data from 232 participating teachers provided needs assessment data and noted necessitated, improved professional development. Professional development typically consists of attending disparate, generally focused workshops or presentations. Site-based professional development differs from traditional professional development in that it involves specific individuals with a defined purpose (Strike et al., 2019). In addition, professional learning targets specific skills to stimulate ongoing professional growth and is revisited regularly. In this study, professional erudition was employed for teacher training, a term referenced throughout the article that encapsulates qualities of both site-based professional development *and* professional learning. Professional erudition offered continuous support to participating teachers throughout the study and established norms for collecting attitudinal and perception data from teachers. These data proved incredibly insightful in understanding the thoughts, perspectives, and the lived experiences of teachers concerning social interactions with students and parents during scientific learning.

Social Connections

Social connections are crucial in shaping collaborative efficacy, thereby supporting collective goals for developing understanding (Schieffer, 2016; Vygotsky, 1978; Woolley et al., 2015). Communication among

parents, students, and teachers is especially advantageous in fostering active collaboration during inquiry activities (Kaufmann & Ryve, 2019). When students participate in socially supportive inquiry, they are more likely to excel both academically and socially (Epstein & Sheldon, 2022; Woolley et al., 2015). For students to actively involve parents, the school environment needs to provide resources for teachers to establish positive relationships between the home and school for social capital (Darling-Hammond, et al., 2002; Darling-Hammond et al., 2016). When children engage with their environment, they have opportunities to shape learning and acquire knowledge (Piaget, 1972). Consequently, heightened interactions between children/students and parents during the completion of school assignments offer experiential learning and a platform for students to develop a deeper understanding (Epstein et al., 2021; Kolb, et al., 1984).

Cognition takes place through Piaget's processes of assimilation and accommodation, where the transformation of existing cognitive structures (assimilation) and the acceptance of new knowledge (accommodation) enables learners to adapt to their environment. Assimilation and accommodation happen simultaneously and alternately throughout one's life. Through these processes, meaning is constructed, and cognitive adaptation occurs (Piaget, 1972). Students with well-developed social networks tend to exhibit increased positive educational outcomes, and similarly, the greater the social supports, the more likely a student is to thrive in school (Darling-Hammond, 2020; Epstein & Sheldon, 2022).

Conceptual Framework

The conceptual framework employed in this qualitative phenomenological study involved utilizing multiple data sets to discern phenomenon and identify emergent themes from phenomenological attitudinal data (Creswell & Poth, 2018; Merriam & Tisdell, 2016; Teddlie & Tashakkori, 2009). A review of literature demonstrated the need for students to develop strong social skills for collaborating with other learners and developing conceptual knowledge (Mahoney et al., 2021). Literature also exhibited the importance of STEM and STEAM in facilitating inquiry, critical-thinking, and problem-solving skills for lifelong learning (Ross, 2011; Shymansky, 2010). When students feel good about learning, they are more likely to engage in constructing knowledge (Kolb et al., 1984; Vygotsky, 1978). The lived experiences, thoughts, and perspectives of students, parents, and teachers are relevant for discerning influential social factors in learning.

Research Objective

The objective of this study was to examine the conditions and influential dynamics of social interactions among students, parents, and teachers. The study sought to identify how students, parents, and teachers perceived one

another as a result of engaging one another during interactive, scientific inquiry learning. The study sought to conceptualize the lived experiences, thoughts, and perspectives of students, parents, and teachers.

Research Questions

This study was conducted to determine the following research questions:

1. What are the influencing emotive and cognitive factors in motivating students to take ownership of science learning in which they became self-managed, self-responsible, and self-directed?
2. What types of social interactions during science learning rendered the development of social capital and what were the perceptions of students, parents, and teachers during these processes?
3. How does forming a community of practice between the home and school in STEAM at the secondary level facilitate social change?

Method

Two teachers participated in professional erudition focused on STEAM instructional methodologies, communications, and engaging parents in science learning. Over a six-week period, 131 parents and students created and maintained dialogue journal entries during experiential, interactive science learning. Dialogue journals served as a platform for parents and students to record thoughts, perceptions, and perspectives regarding social interactions and science learning. The sequence of entries involved students first, followed by parents and then teachers. Students provided their respective dialogue journals to each teacher at the end of each week, and teachers returned the journals to students at the beginning of the following week.

Parents and students were offered a variety of opportunities for reflection, with many of these self-reflective moments arising from dialogue journal entries parents and students crafted while engaging in interactive inquiry activities. Additionally, both parents and students had chances to reflect on their experiences through one-on-one interviews and open-ended questionnaires. Data collected identified themes and were triangulated to reinforce the drawn conclusions.

Rubrics

The researcher provided professional erudition to participating teachers, equipping them with skills to guide students in creating rubrics for self-assessing performances alongside parents. Teachers demonstrated the use of rubrics in assessing growth and facilitated students in developing criteria to evaluate and assess learning. Teachers illustrated the process of creating criteria for measuring actual knowledge and understanding. Students actively participated in developing a rubric, which they then shared with parents for self-assessment. The rubrics, crafted by students, were employed with parents to evaluate student performances.

Student Constructed Exams

The researcher provided participating teachers professional erudition to enhance their skills in guiding students to self-generate and construct examinations. Cooperating teachers utilized these professional erudite opportunities to engage students in the creation of exams that were implemented during the study.

Dialogue Journals

During interactive inquiry learning, parents, students, and teachers documented entries in dialogue journals. The researcher analyzed attitudinal data in these 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.

Student Self-Assessments

Student self-assessments served as the primary instruments for gathering data to evaluate the development of social skills and self-perceptions regarding social interactions. The researcher provided professional erudition to participating teachers, guiding them in incorporating student self-assessments through diverse means, such as student journal entries, student-designed rubrics, and student-constructed exams.

Keyword Search

The researcher utilized keyword search techniques to analyze student, parent, and teacher dialogue journal entries. Keyword search revealed themes and relationships among students, parents, and teachers.

Results

Themes derived from data encompassing dialogue journals, surveys, open-ended questionnaires, one-on-one interviews, and keyword search, were analyzed for comparisons, codification, cross-interpretations, and triangulation.

Rubrics

Attitudinal data from parents and students revealed that the rubrics not only enabled students to participate in assessing their work but also fostered social skills development as students progressed in becoming self-directed, self-managed, and self-responsible learners. In a journal entry, one of the teachers recorded, "The use of the rubrics the students made helped the performance assessments be more objective and assessed students based on their learning."

Student Constructed Exams

Triangulation of attitudinal data from surveys, questionnaires, and interviews revealed that students exhibited an understanding of concepts and science knowledge. Students achieved and developed a sense of responsibility for their own learning and believed constructing their own exams was one of the most influential processes of the study. A participating teacher indicated in a journal entry, "This was easier to do than I originally thought. It helped my students to demonstrate self-responsibility because they controlled their test questions we used to measure their understanding."

Dialogue Journals

Attitudinal data revealed dialogue journal entries created opportunities to establish positive, pro-social relationships with both parents and students. Perceptions from parents and students indicated that the 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.

Student Self-Assessments

Student self-assessments proved to be key in facilitating student growth through self-reflection and identifying standards for achieving and succeeding. Both students and teachers noted the influence self-assessments had in terms of empowering students to make decisions regarding self-success. 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." Providing students opportunities to engage in developing and employing self-assessments afforded learners the freedom to identify and create outcomes for measuring success, which also led to feelings of ownership for learning.

Keyword Search

When concentrating on parents, keyword search revealed positive ideas associated with collaborating with the parent's child. Examining student journal entries via keyword search illuminated ideas connected to conditions influencing support and efficacy development in students, parents, and teachers. Employing keyword search analysis for teacher entries afforded insights into teachers' perspectives on maintaining effective and interactive parental involvement in STEAM learning. Authentic communication consistently emerged as a common thread, interwoven throughout all themes. The participants' experiences were characterized by a unified, supportive, skill-building, self-motivating environment, emphasizing authentic communication as a foundation for building social capital.

Discussion

Dialogue journal entries provided a wealth of self-reflective discourse in which students initiated dialogue, 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. The following attitudinal data provides insight regarding teacher, parent, and student thoughts and their lived experiences highlighting social networking, social capital building, and influences on science learning.

Teachers

A teacher's journal entry stated utilizing the journals fostered student achievement of inquiry learning. "Parents watch the students develop self-responsibility. I think [REDACTED] has given parents insight into children's abilities and growth that would have otherwise not occurred." In another entry, the teacher reflected on accountability as she noted, "Students have become more involved and responsible for their progress. Parent involvement and monitoring through journal entries produced better student participation. I believe this helps students become more responsible for their progress and think it's a key for greater participation. It also helped to improve listening between parents and students and what they had to say. I believe this increased the nature and value of communication in my classroom."

In terms of teachers' thoughts and perceptions regarding social change, teachers recorded a variety of entries as noted below and in Figure 1.

> "*I think it's safe to say that involving the parents also improved the relationship between the parents and me.*"

> "*Students can't get the self-esteem they need developed in high school if they're not supported by parents and teachers. I think that using a project like this has really helped my freshman develop confidence.*"

> "*The most important thing is using the self-assessments. I'm actually surprised at how much of an impact this had so early in the school year. Using the self-assessments with the journaling really made a difference in my students rapport with me….or maybe my rapport with them.*"

One of the participating teachers noted, "using the journal entries were effective in helping the students reflect on their learning and problem-solving skills. It helped parents understand student growth and development." In terms of professional erudition, teachers noted, "I don't think that there would have been such a high level of student success if it wasn't supported by all the professional development. Most of the professional development I get is disconnected from what I really do. There needs to be PD like this if this project is done

with parents again or at another school. It really supported me and made it possible to do it smoothly" and "Giving real professional development was effective and it should be used. I don't understand why we always get the same nonsense."
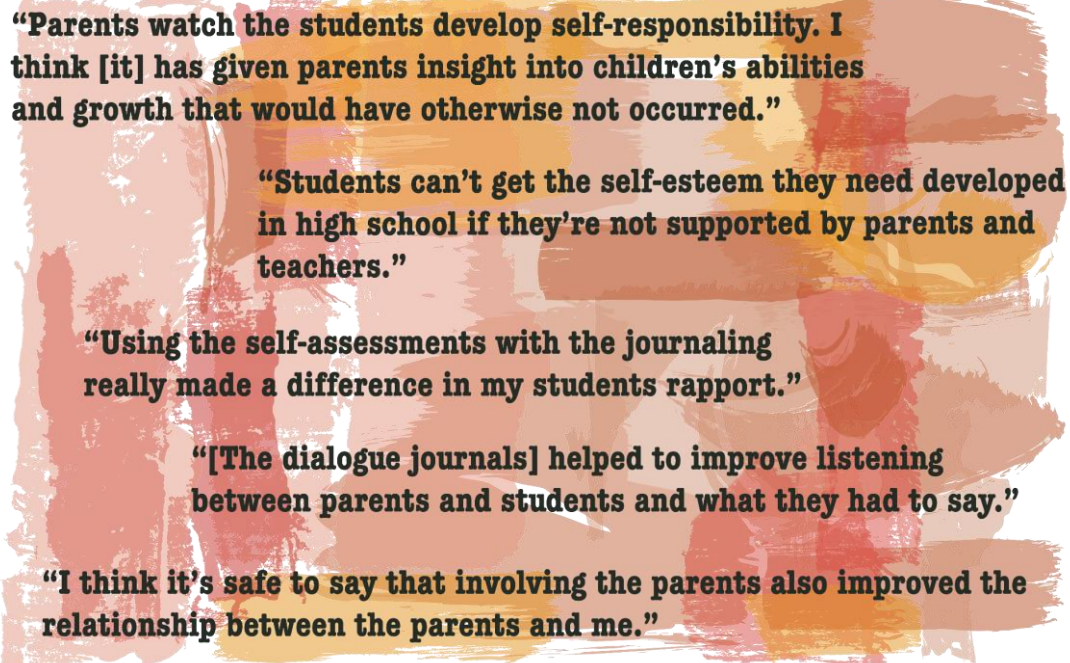

Figure 1. Teacher response exemplars

Parent Responses

During an interview with a parent regarding her experiences corresponding with her child through the dialogue journal, 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. In terms of the dialogue journals, another parent said that she felt like she knew her daughter "better" and the parent "watched [her child] learn and I learned with her." The dialogue journals helped parents and students better communicate and develop a social rapport. These parents indicated that they felt they were able to gauge their children's learning and observe them flourish. A parent stated on a survey that the strategy of designing and choosing questions to answer on the exam assisted his child in becoming more "*responsible for his school work and his grade*" because the child was "*given a lot more control on even the tests and grading*." As a result, the parent concluded that the child "*was responsible for his own work and earned his grade. He worked hard.*" Another parent made a dialogue journal entry that said the student "*never liked science before and now she loves it. Now she knows she can do it*."

Relevant parent responses are noted in Figure 2, with additional exemplars including:

"*I think it will be lots of fun and also a great re-learning experience for me.*" "*It has been a great experience for me and my child to go out and experience nature, at last, from our busy lives. I had a great time!! It was*

an educational experience for my child and a wonderful experience for me." A parent memorialized thoughts regarding social bonding and relationship-building, "*This has been a great opportunity to spend some time and work good together.*"
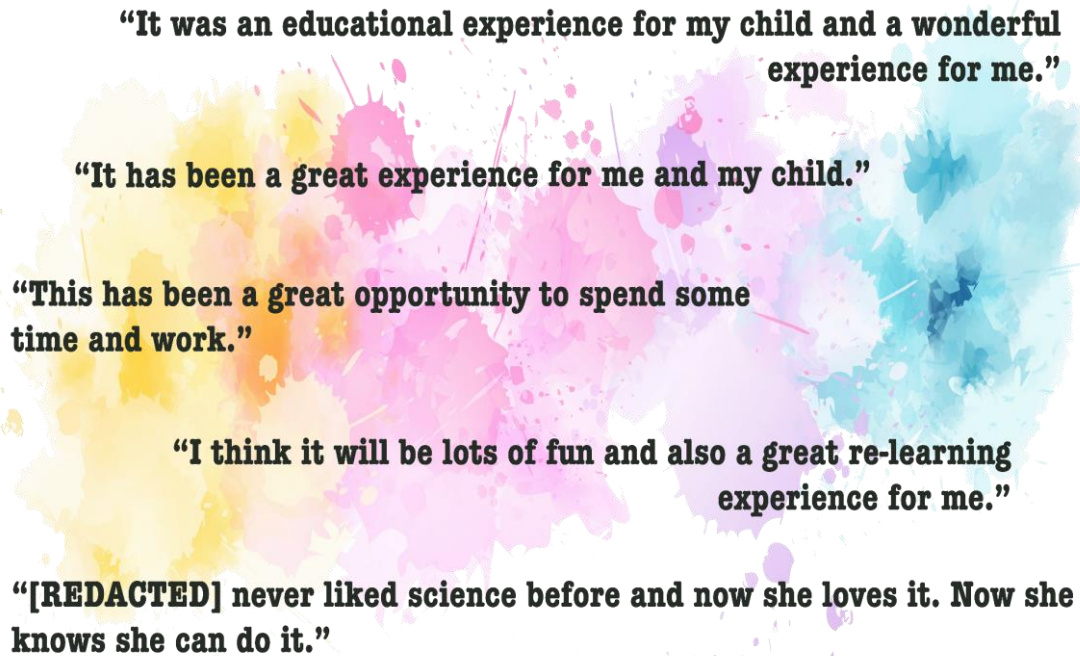

Figure 2. Parent response exemplars

Student Responses

Many students included expressions such as "*felt like a real scientist*" in interviews and on questionnaires they completed. Triangulation supported the assertion that empowering students to create the rubric and exam enabled students to develop social capital to take ownership of the learning. These data indicated that the activities that were most effective in motivating students when implementing strategies were providing students with an authentic experience and enabling students to utilize questioning strategies they could reflect on and create self-assessments.

Formative assessments enabled parents and students to repeat their performances based on reflection and planning strategies to utilize and achieve. When survey data was analyzed, 79.3 % of students surveyed said that the weekly reflection and progress plan entries were helpful in assisting them in developing a better understanding of scientific concepts. During an interview conducted with a student, the student described how the weekly reflection entries helped in the development of inquiry skills. The student stated, "*I thought about what I did and how much I learned and then I thought about how I could do better. So I made a list of stuff I would change next time to improve my work.*" Another student was asked how this involvement strategy helped the student develop inquiry skills and take ownership of the learning. The student responded, "*It's like I learned from my own mistakes. I knew what things I had to change to do better and it was up to me. It was my work.*"

These involvement strategies, coupled with the interactive parent involvement inquiry activity in an authentic setting provided students with an environment and forum in which they could achieve and succeed. Students were enabled to improve their performances through self-reflecting, assessing, and making plans to excel. Students were empowered to take control of the learning and develop self-responsibility and ownership of the work.

Additional, relevant student responses (Figure 3) included:

"*I really do think this project is helping me in my skills to identify things and make assumptions. Since this project requires a lot of organization, it has helped me become much more organized and neater in my work*" and "*My dad helped me use the rubric I made in class. I think we did a great job on this and I liked grading my project with him. We never did that before.*"
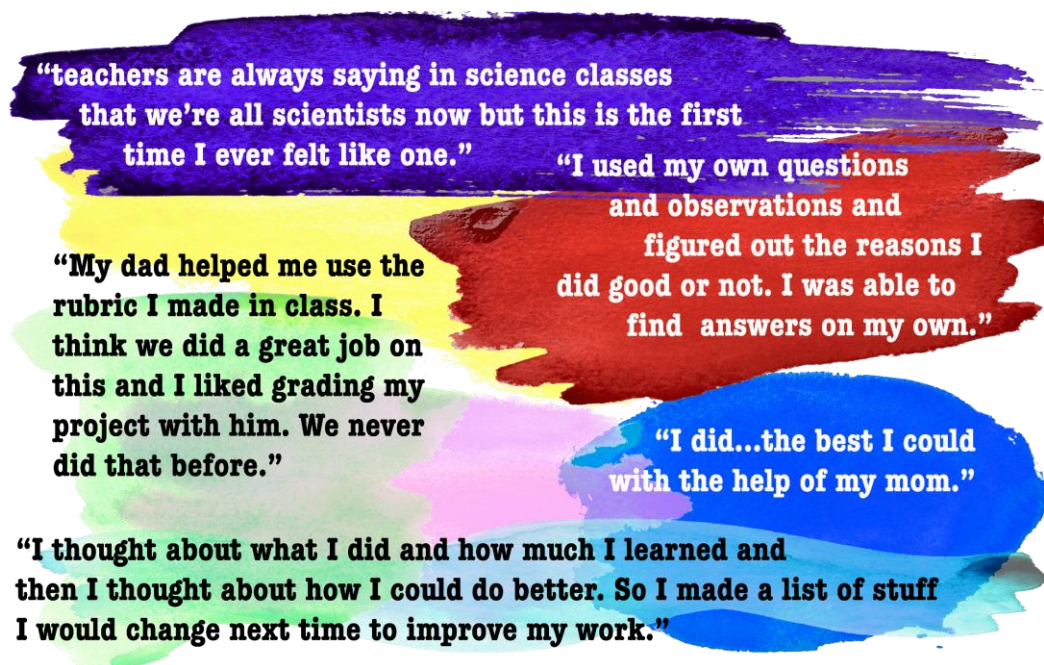

Figure 3. Student response exemplars

Conclusion

The utilization of student-derived rubrics, student-constructed exams, dialogue journal entries, self-assessments, keyword search, interviews, questionnaires, and surveys provided insight regarding the lived experiences of students, parents, and teachers throughout the course of this study. In terms of the influencing emotive and cognitive factors that motivated students to take ownership of science learning in which they became self-managed, self-responsible, and self-directed, a number of key findings were identified (Figure 4). Social influences related to the interactive nature of the learning environment and the ability of students to construct the rubric and parents to partner in identifying criteria for achievement resulted in a sense of efficacy. In addition, the pro-social atmosphere of the learning environment supported students in academically

achieving through the construction of self-assessments and questioning strategies developed during constructivist learning.
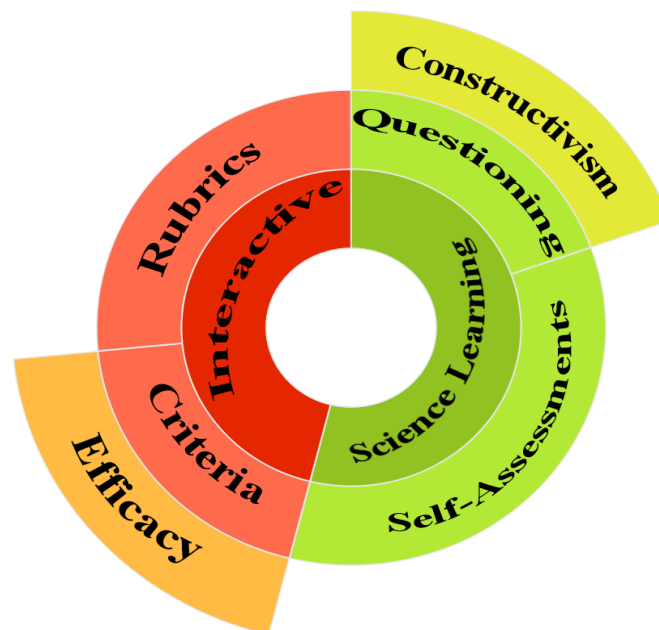

Figure 4. Social environment

Attitudinal data indicates a number of influences concerning the types of social interactions that occurred during science learning that rendered the development of social capital (Figure 5). Students and parents believed a sense of relational reciprocity was prevalent during social interactions, which resulted in motivation and ownership of interactions. Students also developed a sense of self-responsibility, which resulted in feelings of success. Both parent and student data indicated the development of a holistic mindset that resulted in self-evaluation of academic and social performance with a sense of achievement.

Teachers indicated the researcher's development and employment of professional erudition was highly supportive. Teachers felt they developed new skills, which further provided the formation of improved collaborative and communicative skills.
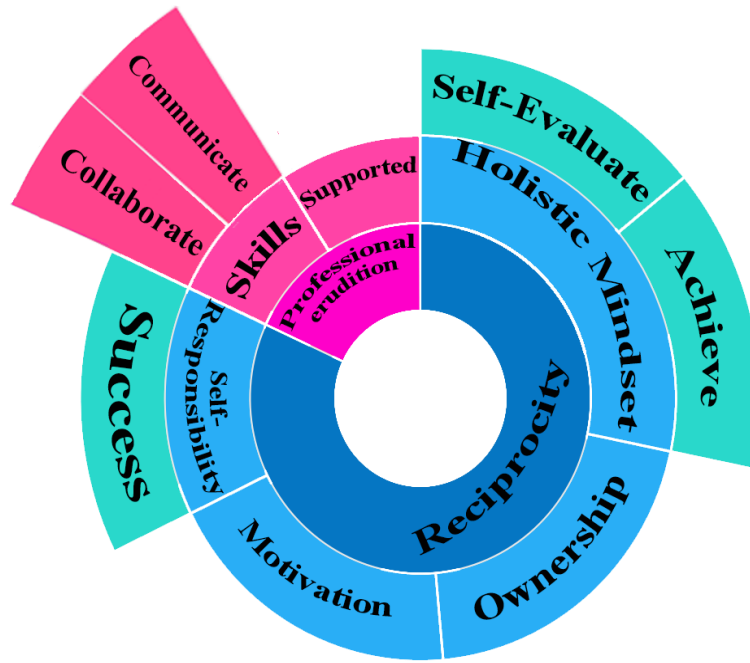
Figure 5. Social perceptions

Data illustrated a community of practice was forged as a result of the formation of a student-parent-teacher participatory partnership (Figure 6). The study's participants felt their partnership was genuine, which resulted in motivation. As a result of social norms development, students and parents perceived self-reflections as inspiring, which created students feeling socially supported. Students and parents also perceived their lived experiences as enjoyable, with journaling being an influencing factor. As a result of their mutual experiences and analysis of attitudinal data, their interactions resulted in positive social change for learning.

Figure 6. Social change

Recommendations

Much like the philosophical construct of STEAM, teaching and learning is a blending of desired outcomes that not only include cognitive, academic achievement, but also comprise the primary success of social skills development. There is an art in delivering meaningful teaching and learning, as there is a science in establishing an atmosphere conducive to supporting meaningful teaching and learning. Employing this conceptualization, if the artist's canvas is professional erudition, each brushstroke first applies layers of social supports followed by painted layers of academics for a portrait of learning. The thoughts, perceptions, and acuities of students, parents, and teachers paint a portrait of the conditions for developing a communal practice for learning. While there are many factors that influence a decline of interactive participation between the home and high school, and in particular, science, there are also authentic strategies that can be employed to facilitate social change and apply paint upon the canvas, one brushstroke at a time.

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