Portraits of Scientific Inquiry and Scientific Literacy Skills Development in Students

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Article Info	Abstract
	Parental involvement generally occurs in elementary school and begins to diminish in middle school. Enlisting parental involvement in high school science is particularly challenging given parents tend to lack their own competencies in terms of scientific knowledge while simultaneously beginning to afford students increased independence. Research was conducted for employing active, meaningful constructivist-grounded parental involvement in high school science. Students participated in constructivist science learning activities with parents that utilized a facet of involvement strategies and socially supportive practices. Parents actively participated and communicated with students during science investigations via collaborative inquiry-based activities, self-assessments, and dialogue journaling. Parents and students participated in interviews, surveys, and questionnaires, as well as maintained dialogue journals for identifying themes. Triangulation of data identified the most effective strategies for involving parents in science learning and the impact of involvement on the development of student scientific inquiry and scientific literacy skills. Data indicated an increase in the development of scientific inquiry and scientific literacy skills in both parents and students, as well as student social, emotional achievement.

Introduction

A student's home environment and varying levels of parental support are amongst the most influential factors that impact student learning (Epstein & Sheldon, 2022; Shymansky, Yore, & Hand, 2010). Data indicates factors such as family influence and student self-interests beyond the traditional school-learning environment

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impact students' interests in core science areas and Science, Technology, Engineering, and Mathematics (STEM) education (Funk & Hefferon, 2016). In addition, collaborative learning and integrated learning experiences impact students' interests in both science and STEM and are influential in providing supportive science and STEM learning experiences for students (Barakos, Lujan, & Strang, 2012; Brown et al., 2011). While parental involvement in student learning is more pervasive at elementary grade levels as opposed to high school grade levels, highly structured, core-specific science and STEM learning takes place in high school as opposed to elementary school. The ability to support the development of scientific inquiry and literacy skills in student courses is enhanced by home engagement, and while STEM ad STEAM (Science, Technology, Engineering, Art, and Mathematics)-specific course enrollment increases during high school, parental involvement tends to decrease as students' progress from elementary grade levels high school (Epstein & Sanders, 1998; Funk & Hefferon, 2016).

Parental involvement creates a dialogue that enables an environment to exist that supports a free exchange of ideas and statements (Epstein, 1995). Social support is central in developing an environment that supports not only learning but also empowers students to attain knowledge (Mahoney et al., 2021). When students engage in group learning activities and reflect on learning, they develop an increased understanding of central principles (Luft & Pizzini, 1998). The benefits of family involvement in improving students' academic performance is well documented, as is the influence of parental involvement in science learning (Maiorca et al., 2021; Wang, Haertel, & Walberberg, 1997).

Enabling parents to participate in hands-on science activities with students facilitates direct involvement and acts as a catalyst in helping students take ownership of key concepts and the learning. Many parents report performing hands-on science activities with their children as engaging and are interested in being actively involved in their student's learning (Russell, 1996). However, parents perceive their abilities as lacking in terms of content knowledge and capacity in guiding students to develop conceptual and concrete understanding and knowledge (Silander et al., 2018). Involving parents is imperative if students are to make the connections necessary in taking ownership of new concepts. Parents provide guidance in challenging students' abilities in which the learning becomes more relevant in developing understanding of concepts (Huitt & Hummel, 2003). Utilizing parental involvement in science activities that extend to the home fosters active, collaborative engagement of students, the ability to construct knowledge, and ownership of the learning.

Constructivism

Constructivism is a teaching methodological process tool for instructors to employ in science classrooms that provides students with more control of the learning and a forum to demonstrate the acquisition of knowledge.

Constructivism provides learners opportunities to construct knowledge via experiential learning (Kolb, 2014; Piaget, 1972). Providing students and parents opportunities to engage in experiential, constructivist learning provides a forum for both parental engagement in high school science as well as home-school supports. Additionally, the process of constructing knowledge provides learners with opportunities to design investigations and utilize inquiry skills through collaboration, making decisions, and developing answers for understanding (Bruner, 1996). When students engage in constructing knowledge and self-assess their own progress, they develop a deeper understanding of curricular objectives and outcomes that enhances constructivist constructs (Dewey, 1933; Perkins, 1999).

Utilizing constructivist-grounded, interactive homework, activities, and investigations provides foundational supports for actively engaging parents to support both student self-concept and academic achievement (Battle-Bailey, 2003). Utilizing experiential, interactive homework, activities, and investigations also supports students when they partner with parents, draw conclusions, and construct knowledge regarding home learning activities. The interaction of parents on homework, activities, and investigations supports the academic and social development of students by providing continual feedback, guidance, and suggestions for improvement. Thus, constructivist, experiential, interactive parental involvement provides opportunities for the facilitation of ownership of science learning in students (Kolb et al., 1984; Piaget, 1972).

Supportive relationships result in emotional attachments, interpersonal skills development, and systems of supports for students to achieve and succeed (Darling-Hammond et al., 2020). In an effort to promote constructivist scientific inquiry and literacy skills development in students, enlisting supportive, reciprocal home engagement and involvement supports the whole child in terms of science learning and social skills development. Thoughtfully designed systems of supports promote social, emotional, and academic achievement for all learners (Osher et al., 2018). Engaging parents and providing homework, learning activities, or scientific investigations ground in inquiry provokes active learning, questioning, and applications of knowledge (Darling-Hammond et al., 2020).

Factors in Declining Parent Involvement

Home-school relationships decline at the secondary level, which often inhibits active parent involvement. The decline in parental involvement at the high school level is influenced by students beginning to establish independence as adolescents and parents enabling student self-sufficiency (Catsambis & Garland, 1997; Epstein & Sheldon, 2022). Moreover, parents perceive diminished confidence in terms of their own science content knowledge, which severely lessens and challenges parental involvement in high school science learning. Adolescents do, however, need the continued guidance and support of parents as they mature and

assume greater and responsibilities. Major areas of decline include discussions about school, homework, and assisting students with homework (Epstein et al., 1999).

As a countermeasure to this phenomenon, teachers at the secondary level can foster greater support by engaging parents in learning activities to form partnerships and support students. Actively engaging and creating dialogue with parents in learning activities facilitates enhancing learning opportunities. (Epstein & Sanders, 1998; Epstein et al., 1999; Rutherford, Anderson, & Billig, 1995). Relationships between parents and children change as students mature. Children tend to become more confident in their abilities while parents tend to become less confident in their ability to engage in course content. A supportive, trusting atmosphere between the home and school is crucial for facilitating a relationship in which students and parents' partner with the school on interactive inquiry activities and self-assessments (Darling-Hammond et al., 2002; Darling-Hammond et al., 2016).

Facilitating the Development of Scientific Inquiry and Scientific Literacy Skills

The National Science Teaching Association (NSTA) encourages parents to become actively involved with science learning at school, partner with students, and engage in direct communications with science teachers to encourage students to engage in STEM (NSTA, 2009). Likewise, the National Parent Teacher Association (NPTA) provides a framework for how families, parents, and students should work together as active partners with schools. The NPTA's standards advocate for family-school relationships that are welcoming for all families, proactively communicative, and to forge partnerships for setting academic, social, and emotional goals for contributing to classroom learning and at home learning (NPTA, 2022).

Factors, such as the learning environments of learners and teachers' pedagogical and methodological positionality directly impact scientific literacy development of students (Palines & Cruz, 2022). Data also indicates that high school students with poor scientific inquiry and literacy skills do not use critical thinking skills for analyzing information. Probable cause data indicates these students obtain little joy in learning and that the development of higher-level thinking skills directly correlates to the degree students take ownership of the learning. Additionally, a number of influential factors impact academic achievement, including home learning resources and parental instruction and involvement (Shymansky, Yore, & Hand, 2010). For students to be actively involved, they need to become self-directed in learning. When students analyze and prioritize questions they propose with parents, they are empowered to derive explanations about the world around them. Students are better able to take control of the learning and make connections based on their inquiries.

Students develop scientific literacy through processes that provide them opportunities to experiment, employ hypothetical-deductive reasoning, and evaluate findings (Bowyer, 1990). Scientific literacy is also a predictor of student inquiry behavior, which supports the acquisition of literacy skills (Wen el al., 2020). Increasing student scientific literacy skills is a life skill students can employ as lifelong learners. Providing students a guided inquiry-based learning environment supports students' science achievement for developing both scientific inquiry and literacy skills (Wen el al., 2020).

Instructional Strategies for Engagement and Learning

Interactive Homework

Although parents begin to feel less confident about helping students with science homework as they progress from primary to secondary school, parent involvement impacts student perceptions and motivation to learn. Interactive homework is situational and socially constructed to directly engage parents or family members in homework activities (Epstein et al., 2021). Providing students repeated interactive, socially supported homework facilitates the development of individual interest in science learning (Renninger & Su, 2012). When parents demonstrate a genuine interest in homework, their interest facilitates student interest, which influences self-directed and self-managed homework assignment completion (Battle-Bailey, 2003). Interactive homework is a catalyst for essential interactions amongst the school and home, and for child rearing by the adults responsible for providing care for learners (Walker et al., 2004).

Reflections via Dialogue Journals

Providing parents and students opportunities to engage one another via interactive homework facilitates students leading conversations regarding school learning. These positive, student-led conversations are pro-social and lead to positive feelings in parents regarding insight of high school student learning (Epstein et al., 2021; Howard et al., 2020). Providing Parents and students interactive homework also provides opportunities for parents and students to ask questions, self-reflect, and self-assess. Dialogue journal writings can be pen-and-paper or electronic, but either way, they provide further opportunities to memorialize perceptions, questions, and knowledge for deeper learning. The process of recording thoughts is relational and creates a back-and-forth rapport between teacher, students, and parents (Chan & Aubrey, 2021; Stillman et. al., 2014).

Self-Assessments and Formative Assessments

Student self-assessments positively impact student achievement and self-regulated learning. When self-assessments occur through meaningful learning activities, students engage in learning-oriented self-reflections

for improvement (Yan, 2020). Students are frequently evaluated through the use of summative assessments, which are final grades for a particular assignment, exam, or unit of study. Formative assessments are ongoing and afford students opportunities through feedback to repeat performances for mastery. Formative assessments also influence self-regulated learning. Science teachers should develop and employ both formative and summative assessments to provide students experiences with multiple modes of assessing (Artler & Spandel, 1992). Enabling students to initiate self-assessments during learning activities also augments the effectiveness of formative assessments (Lee et al., 2020).

Conceptual Framework

The conceptual framework of this qualitative phenomenological study involved employing an in-depth analysis of a phenomenon using multiple data sources within bounded, real-life, contemporary contexts or settings (Creswell & Poth, 2018; Merriam & Tisdell, 2016; Teddlie & Tashakkori, 2009). Literature reviewed supports the assertion that 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 conduct an interactive investigation inquiry activity with their child and to document growth and performances by maintaining weekly entries in dialogue journals. These personal reflections and self-evaluations by students and parents served as a method for documenting the development of scientific inquiry and literacy skills and ownership of the learning in students.

Research Objective

The objective of this study was to identify a model of the most effective strategies and methodologies that could be successfully employed at the high school level to enlist parental participation with students during science inquiry investigations. As children progress from lower grade levels to upper grade levels, the level of parental involvement decreases. These data present a negative correlation in an inverse relationship of home-school involvement, which was the impetus for the research conducted. Parents and families may possess a partnership with the school during the duration of a child's education, but parent and family involvement decreases as students advance from elementary to high school (Epstein & Sanders, 1998).

Research Questions

This study was conducted to determine the following research questions:
1. What are the most effective strategies and methodologies that can be successfully employed at the high school level to enable and empower parents to research with their child and document growth and performances during science inquiry investigations?

2. In which ways does parental involvement in high school impact or contribute to the development of scientific inquiry and scientific literacy skills in learners?

3. What are the social, emotional implications of parental involvement with students as a result of strategies and methodologies employed in this study?

Method

Research Design

This study employed a qualitative, emergent phenomenological design based in the tradition of portraiture, which shares many of its features with ethnography, case study, and narrative (Lawrence-Lightfoot & Davis, 1997). Utilizing a qualitative, emergent phenomenological design also provided objective and subjective perspective with respect to the impact of shared experiences on parental involvement and scientific knowledge acquisition. (Creswell & Poth, 2018). The intersection and interconnectedness of shared experiences provided an understanding of the essence of the phenomenon being studied (Prosek & Gibson, 2021). Collectively, utilizing a qualitative, phenomenological construct provided a framework for interpreting emergent themes, analyzing data, and making meaning of the influence of parental involvement in high school science.

Data Collection Procedures

Dialogue Journals

One hundred thirty-one parents and students created and maintained weekly dialogue journals. As students engaged in constructivist, interactive science activities with parents, students first completed journal entries, read and responded to by parents and then provided to the classroom teacher at the end of each week. The classroom teacher reviewed, commented, and returned journals to students at the onset of the next week.

Parent Ranking Survey

One hundred twenty-six parents completed a ranking survey with respect to the most effective strategies employed during the study. The survey included the possible ways parents may have been involved and interacted with their child during the inquiry activity.

Open-Ended Questionnaires

During the course of this study, 118 parents completed the open-ended questionnaire. One hundred nineteen students completed the open-ended questionnaires. Parents and students participated in completing self-

assessments regarding dialogue journals and designing rubrics during the study to measure and record student growth and success as a result of students constructing understanding.

Student Survey

One hundred twenty-nine students completed a survey on the most effective strategies utilized over the course of the study. Students were provided self-assessment opportunities on surveys. These data were triangulated and utilized to discern the development of self- responsibility and ownership of the learning based on student self-assessment responses.

Interviews

The researcher conducted one-on-one interviews with 20 pairs of participating parents and students. Interviews were one-hour in length and were employed to qualify findings and develop an understanding of parent and student feelings and perceptions. Interviews were transcribed and coded by employing inter-rater reliability. Participants were provided opportunities during interviews to provide self-assessments regarding the development of self-responsibility and ownership of the learning. Interviews also focused on the impact the study had on students' scientific research development.

Results

Emergent themes between participants were codified to determine correlations. Cross-interpretations and triangulation of attitudinal data assisted in the identification of emergent themes and improved trustworthiness of these data through inter-rater reliability. Themes from data were compared to one another from participants' dialogue journals, open-ended surveys, questionnaires, and one-on-one interviews. Student self-reflections empowered students and served in accurately measuring progress and the acquisition of scientific inquiry and scientific literacy skills. Consequently, these data were also indicators of students developing self-responsibility and taking ownership of the learning.

Students and parents engaged in creating self-assessments and rubrics for use in classroom activities with teachers. These strategies and multiple forms of data measured the development of problem-solving skills and the accuracy of student-developed products and rubric effectiveness. Themes identified from these data were compared to data in students' self-assessments to view patterns more clearly. Triangulating these forms of inter-rater data enabled the identification of relationships amongst themes and subthemes by comparing and contrasting codified data. Data collected through parent and student self-reflections and self-assessments in

dialogue journals enabled the discernment that engaging in constructivist problem solving with parents at the high school level resulted in an increase in students developing self-responsibility and ownership of the learning. Students maintained portfolios with parents regarding scientific engagement artifacts for self-review.

Dialogue Journals

These personal reflections and self-evaluations by students and parents served as a method for documenting the development of scientific inquiry and literacy skills, feelings regarding experiences, and ownership of the learning in students.

Parent Ranking Survey

The survey provided insight regarding the ways parents were involved and interacted with their child during the inquiry activities. Parents indicated the methods they employed and ranked the methods according to feelings of their individual importance or effectiveness (Table 1 and Figure 1).

Table 1. Parent involvement methodologies of perceived importance ranked

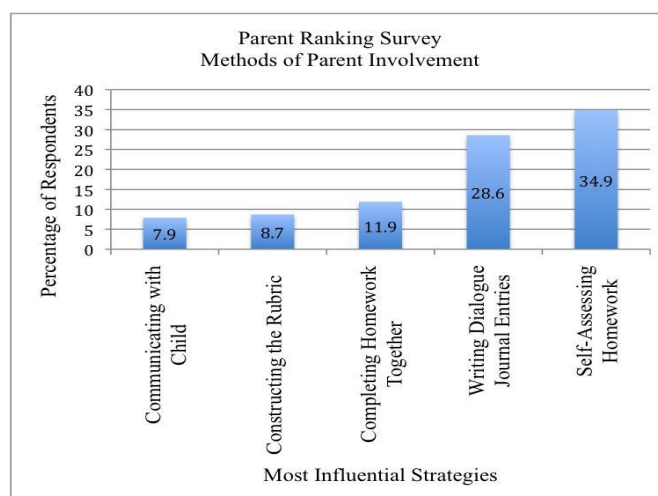| Methodology	Percentage of Importance
Self-Assessing Your Child's Work	34.9%
Writing Dialogue Journal Entries	28.6%
Completing Homework Activities	11.9%
Making a Rubric with Your Child	8.7%
Talking with Your Child About Performance, or Progress	7.9%
Making Self-Reflections	5.5%
Other	2.5%

Figure 1. Parent rankings of most influential strategies

Open-Ended Questionnaires

The questionnaires revealed students' reflective practice in terms of the various products they produced and self-assessed information that was important and vital. Student self-reflections empowered students and served in accurately measuring progress and the acquisition of scientific inquiry and literacy skills. Consequently, these data were also indicators of students developing self-responsibility and taking ownership of the learning.

Student Survey

These self-assessment opportunities enabled the investigator to identify patterns and themes. Data indicated students were empowered to take ownership of the learning through reflecting and modifying their performances to achieve and succeed (Figure 2).
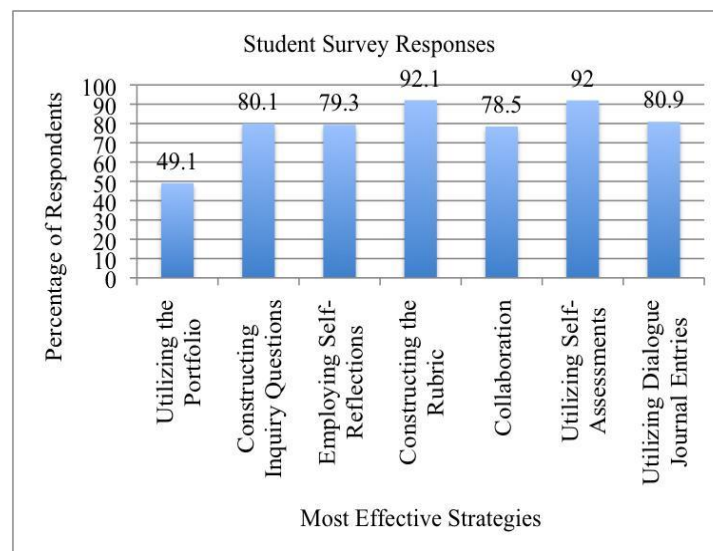

Figure 2. Student rankings of most effective strategies

These data were compared, contrasted, and correlated with findings from parent survey responses regarding the most effective strategies for engaging students and facilitating acquisition of student learning (Figure 3). Correlations were performed between all of these data sources in determining effectiveness of these strategies and methodologies.
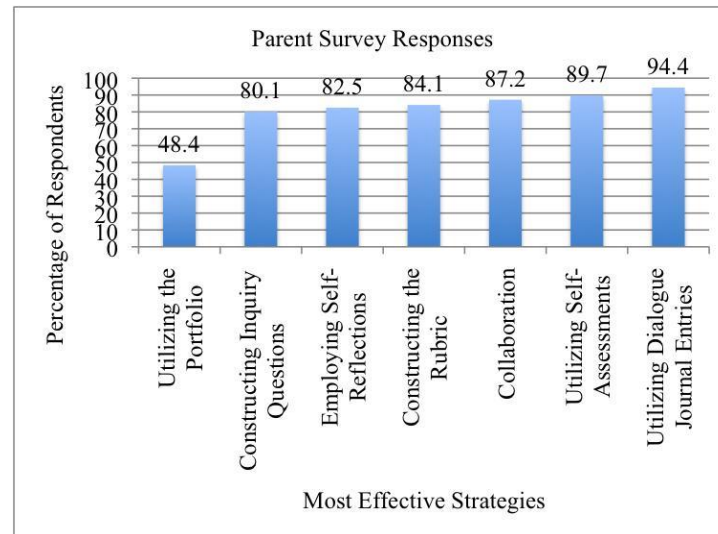
Figure 3. Most effective strategies for engaging students

Interviews

The researcher conducted one-on-one interviews with 20 pairs of participating parents and students. Interviews were employed to qualify findings and develop an understanding of parent and student feelings and perceptions. Interviews were transcribed and coded by employing inter-rater reliability. Participants were provided opportunities during interviews to provide self-assessments regarding the development of self-responsibility and ownership of the learning. Interviews also focused on the impact the study had on students' scientific research development. Parental and student reflections indicated that students were provided opportunities to make self-evaluations and self-assessments of their progress and performances to make much needed adjustments to flourish as lifelong learners. Parent responses are illustrated in Figure 4 below.
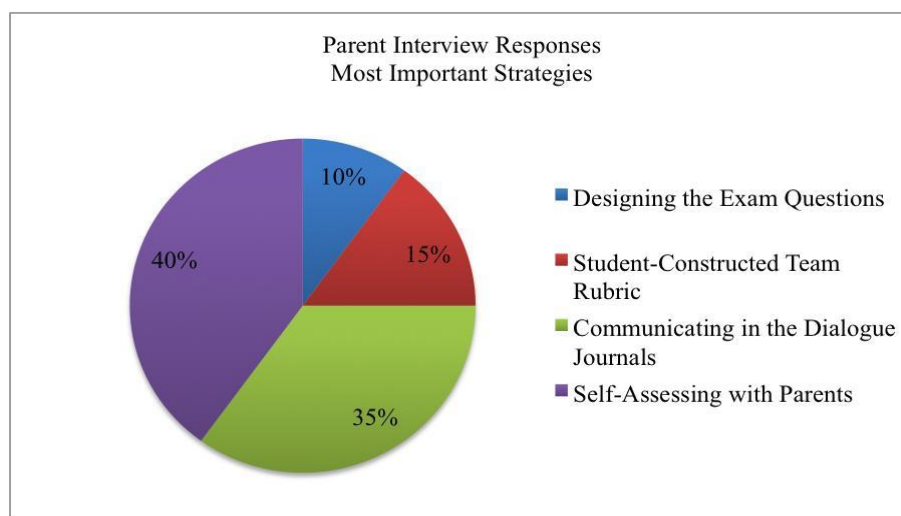

Figure 4. Parent interview responses of most important strategies

Interview data indicated the most important involvement strategies for assisting students in developing scientific inquiry and scientific literacy skills were utilizing self-assessments, designing self-assessments, and communicating in dialogue journals. Both parents and students (Figure 5) indicated the ability for students to self-assess progress was the most effective strategy. While students indicated creating a team-rubric with parents, followed by journaling, were the next most effective strategies, parents indicated the same two involvement strategies with dialogue journals followed by the rubric as most important. All three strategies are interconnected and correlate with one another, as they empower students to continually measure performance while constructing evaluations of progress.
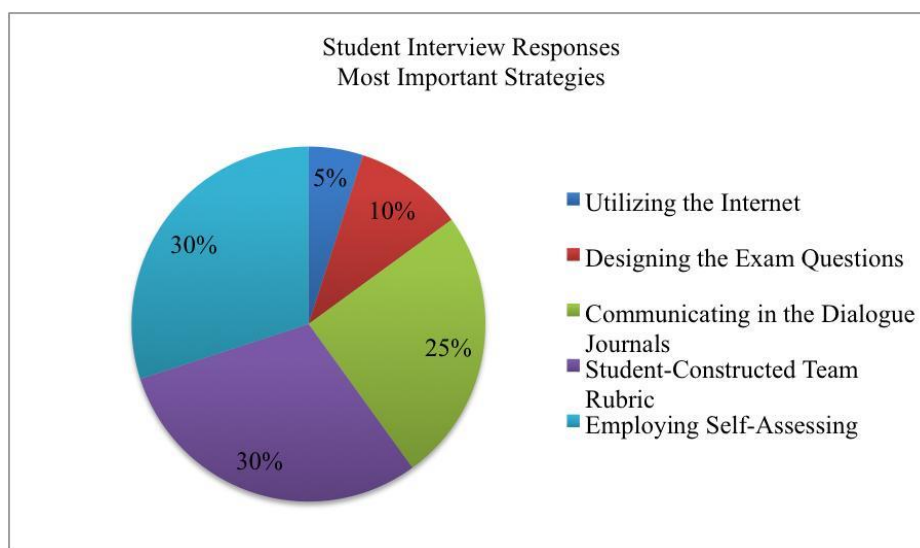

Figure 5. Student interview responses of most important strategies

Discussion

Three emergent themes were identified in all data sources (collaborative, communicative, and supportive). In addition, three major relationships were identified (interactive, proactive, and motivative). The identification of emergent themes and relationships resulted in the identification of the most effective strategies and methodologies that can be successfully employed at the high school level to enable and empower parents to research with their child and document growth and performances during science inquiry investigations. In terms of the most effective strategies and methodologies that can be successfully employed at the high school level to enable and empower parents to research with their child, interactive homework, collaborative inquiry-based activities, self-assessments, and dialogue journaling were most effective.

Data also revealed parental involvement in high school science contributes to the development of scientific inquiry and scientific literacy skills in students. The ability of students to assess their own learning in concert with reflecting and constructing rubrics enables learners to consider learning objectives and skills that reflect mastery of learning outcomes. As a result, students are positioned to proactively develop, employ and then assess scientific inquiry and scientific literacy skills. Students are empowered to develop scientific inquiry and scientific literacy skills via interactive and collaborative constructivist learning opportunities that are communicative.

In addition, parental involvement with students during high school science activities possesses social, emotional implications. The strategies and methodologies employed in this study demonstrated collaborative, involvement strategies are supportive and facilitate the development of self-responsibility and self-management skills in students. Both students and parents reported feeling motivated to learn, with data also indicating an increase in student efficacy as a result of collaborating, communicating, and self-assessing science learning.

The outcomes also indicate parental involvement must be interactive to ensure increased parental involvement. In order for this model to be effective in other schools and communities, parents and students must be provided interactive, collaborative opportunities supported by dialogue journaling. It is not enough to simply invite parents to perform science learning activities with students. Parents must be provided opportunities to engage in active, reciprocal dialogue and constructivist learning opportunities that are challenging and motivational. Parents believed they possessed ownership in the academic and social aspects of this study, which resulted in increased efficacy and social change in the learning community. In order for this model to be applied in other communities, schools, and districts, teachers need to utilize their skills and employ interactive inquiry activities that enable parents and students to utilize questioning strategies and ongoing self-assessments. Parents and students believed the self-assessments and self-reflections they created resulted in a collegial environment conducive to fostering scientific inquiry and scientific literacy acquisition. The science learning parental involvement proposed in this study emphasized social learning opportunities concurrent with cognitive learning opportunities.

Conclusion

The outcomes of this study supported the active involvement of parents in high school science fosters motivation, ownership of learning, improved efficacy, and a holistic mindset to develop in students. The interactive, collaborative parent involvement strategies utilized in this study also fostered improved social skills in students. Supportive collaboration fostered motivation in students, while self-evaluations and self-reflections

provided opportunities for a supportive, collaborative, and communicative environment to develop. In addition, self-responsibility and self-management skills in students increased. The results were improved student efficacy and a holistic mindset to develop not only in students, but also in parents. Lastly, authentic, interactive involvement of parents motivated parents to both engage in science learning in addition to actively partnering in learning with teachers.

The involvement strategies parents and students employed motivated parents and students to develop scientific inquiry and scientific literacy skills and 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 were the result of students participating in activities 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 the learning was memorable and meaningful. Students were an integral component of the learning and controlled the knowledge ascertained. Parents actively participated and communicated with students, which created a supportive network and partnership. Students were enabled to gain knowledge as a result of utilizing questioning strategies to derive solutions and construct meaning. 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 rubric construction to note their understanding of the key concepts and learning goals. It can be concluded that utilizing these strategies on a daily basis enables students to develop skills they can use throughout a lifetime of learning.

Recommendations

Data indicates the active involvement of parents in science learning activities at the secondary level supports students' acquisition of scientific inquiry and scientific literacy skills and increased parent and student efficacy. The participants in this study believed they were able to form strong partnerships as a result of utilizing proactive communications and interactive collaborations during scientific inquiry activities. Students believed their willingness to collaborate with parents increased during the inquiry activity, which was contrary to student beliefs prior to engaging parents. Therefore, utilizing involvement activities grounded in proactive communications should be employed to encourage collaboration and improve the efficacy of both parents and students.

While parental involvement declines at the secondary level, this study provided a salient example of utilizing supportive, communicative, interactive inquiry activities to reverse this trend. In addition, parents are less likely to participate in high school science learning with students as a result of insecurities regarding parent science

knowledge and inquiry skills. This study demonstrates augmenting practices to develop partnerships between the home and school enlists parental involvement in high school science. The outcomes clearly support constructing supportive high school science learning environments to form partnerships between the home and school. In an effort to reverse parental involvement trends, a combination of shared decision-making and the ability to reflect and self-assess progress are central in constructing science involvement learning environments.

Data indicated motivational support and interactive collaboration are the conditions required to successfully construct a supportive learning environment to form partnerships. Parents and students increased their sense of ownership of the learning as a result of the supportive, communicative relationship formed between teachers, parents, and students. Parent and student data indicate the most important strategy utilized in this study was the use of the dialogue journals. Dialogue journal data indicated parents felt they were partners in the decision-making and engaged in a participatory, supportive and communicative activity between the home and school. Parents perceived their involvement as genuinely received. Parental confidence increased, which resulted in parents believing they could succeed as a team with their child. High School science involvement activities must include opportunities for participatory, reciprocal, self-reflections for assessing progress. The utilization of dialogue journals provided students and parents to reflect on their performances as a team and as individuals.

The most effective strategies that can be successfully employed at the high school level to enable and empower parents to research include interactive, collaborative inquiry-based activities, self-assessments, and designing rubrics. Therefore, programs should be designed to include opportunities for students to consider curricular outcomes of their science learning by considering elements for inclusion in rubrics. The development of scientific inquiry and scientific literacy skills in students was enhanced through students being able to self-assess learning and construct rubrics for use in science learning. Collaborative parental involvement enables and empowers parents to research with their child to document growth and performances during science inquiry investigations. Parent and student data indicates self-assessments are highly effective in supporting collaboration and enables students to form questions and look for answers to their questions. Self-assessments and rubric construction are catalysts for providing a forum for these strategies to be employed and are central in designing similar programs for student success.

The outcomes of this study support actively involving parents in science learning fosters communication and collaborative skills, which fosters the development of social skills in students. The active involvement of parents fosters motivation, ownership of learning, improved efficacy, and a holistic mindset to develop in learners. The interactive, collaborative parent involvement strategies utilized in this study fostered improved social skills in students and should be employed in similar programs. Supportive collaboration fosters

motivation in students. Utilizing this strategy facilitates self-responsibility and self-management skills development in students. Utilizing this programmatic design construct results in improved student efficacy and a holistic mindset to develop not only in students, but also in parents.

References

Arter, J. A., & Spandel, V. (1992). Using portfolios of student work in instruction and assessment. *Educational Measurement: Issues and Practice 11*(1), 36–44. https://doi.org/10.1111/j.1745-3992.1992.tb00230.x

Barakos, L., Lujan, V., & Strang, C. (2012). *Science, technology, engineering, mathematics (STEM): Catalyzing change amid the confusion*. Portsmouth, NH: RMC Research Corporation, Center on Instruction.

Battle-Bailey, L. (2003). *Training teachers to design interactive homework.* ERIC Digest on Teaching and Teacher Education. Washington DC.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher, 70*(6), 5-9.

Bruner, J. (1996). *The culture of education*. Cambridge, MA: Harvard University Press

Bowyer, J. (1990). Scientific and technological literacy: education for change. *Special Study for the World Conference on Education for All, 48,* 12-35.

Catsambis, S., & Garland, J. (1997). *Parent involvement in students' education during middle school and high school.* Queens College, CUNY. Center for Research on the Education of Students Placed At Risk (CRESPAR).

Chan, P. H., & Aubrey, S. (2021). Strengthening teacher-student rapport through the practice of guided dialogue journaling. *RELC Journal*. https://doi.org/10.1177/00336882211044874

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage. https://doi.org/10.1177/1524839915580941

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process.* DC Heath.

Darling-Hammond, L., Ancess, J., & Ort, S. W. (2002). Reinventing high school: Outcomes of the coalition campus schools project. *American Educational Research Journal, 39*(3), 639–673. https://doi.org/10.3102/00028312039003639

Darling-Hammond, L., Ramos-Beban, N., Altamirano, R. P., & Hyler, M. E. (2016). *Be the change: Reinventing school for student success*. New York: Teachers College Press.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97-140. https://doi.org/10.1080/10888691.2018.1537791

Epstein, J. L. (May 1995). School/family/community partnerships: Caring for the children we share. *Phi Delta Kappan, 76*(9), 701–712. https://doi.org/10.1177/003172171009200326

Epstein, J. L., Mac Iver, D. J., Mac Iver, M. A., & Sheldon, S. B. (2021). Interactive homework to engage parents with students on the transition from middle to high school. *Middle School Journal, 52*(1), 4-13. https://doi.org/10.1080/00940771.2020.1840959

Epstein, J. L. & Sanders, M. (1998). *School-family-community partnerships in middle and high schools: From theory to practice.* Johns Hopkins University and Howard University. Baltimore, MD.

Epstein, J. L., Sanders, M. G., & Connors-Tadros, L. (1999). *Family partnerships with high schools: The parent's perspective.* Johns Hopkins University and Howard University. Baltimore, MD.

Epstein, J. L., & Sheldon, S. B. (2022). *School, family, and community partnerships: Preparing educators and improving schools* (3rd ed.). Routledge. https://doi.org/10.4324/9780429400780

Funk, C., & Hefferon, M. (2016, October). As the need for highly trained scientists grows, a look at why people choose these careers. *Pew Research Center, 1–5.* https://policycommons.net/artifacts/618227/as-the-need-for-highly-trained-scientists-grows-a-look-at-why-people-choose-these-careers/1599135/

Howard, J., Milner-McCall, T., & Howard, T. (2020). *No more teaching without positive relationships*. Heinemann.

Huitt, W., & Hummel, J. (2003). *Piaget's theory of cognitive development.* Educational Psychology. Valdosta, GA: Valdosta State University Press.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT press.

Kolb, D. A., Rubin, I. M., & McIntyre, J. M. (1984). *Organizational psychology: readings on human behavior in organizations*. Englewood Cliffs, NJ: Prentice-Hall.

Lawrence-Lightfoot, S. & Davis, J. (1997). *The art and science of portraiture.* San Francisco, CA. Jossey-Bass.

Lee, H., Chung, H. Q., Zhang, Y., Abedi, J., & Warschauer, M. (2020). The effectiveness and features of formative assessment in US K-12 education: A systematic review. *Applied Measurement in Education, 33*(2), 124-140. https://doi.org/10.1080/08957347.2020.1732383

Luft, J. A., & Pizzini, E. L. (1998). The demonstration classroom in-service: Changes in the classroom. *Science Education*, *82*(2), 147-162.

Mahoney, J. L., Weissberg, R. P., Greenberg, M. T., Dusenbury, L., Jagers, R. J., Niemi, K., Schlinger, M., Schlund, J., Shriver, T. P., VanAusdal, K., & Yoder, N. (2021). Systemic social and emotional learning: Promoting educational success for all preschool to high school students. *American Psychologist, 76*(7), 1128. https://psycnet.apa.org/doi/10.1037/amp0000701

Maiorca, C., Roberts, T., Jackson, C., Bush, S., Delaney, A., Mohr-Schroeder, M. J., & Soledad, S. Y. (2021). Informal learning environments and impact on interest in STEM careers. *International Journal of Science and Mathematics Education, 19*, 45-64. https://doi.org/10.1007/s10763-019-10038-9

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research A guide to design and implementation* (4th ed.). Jossey-Bass.

National PTA. (2022). PTA national standards for family-school partnerships: An implementation guide.

National Science Teachers Association. (2009). NSTA position statement: Parent involvement in science learning.

Osher, D., Cantor, P., Berg, J., Steyer, L., & Rose, T. (2018). Drivers of human development: How relationships and context shape learning and development. Applied Developmental Science, https://doi.org/10.1080/10888691.2017.1398650

Palines, K. M. E., & Cruz, R. A. O. D. (2021). Facilitating factors of scientific literacy skills development among junior high school students. *LUMAT: International Journal on Math, Science and Technology Education, 9*(1), 546-569. https://doi.org/10.31129/LUMAT.9.1.1520

Perkins, D. (1999). The many faces of constructivism. *Educational Leadership*, Nov. 6-11.

Piaget, J. (1972). *The psychology of the child*. New York: Basic Books.

Prosek, E. A., & Gibson, D. M. (2021). Promoting rigorous research by examining lived experiences: A review of four qualitative traditions. *Journal of Counseling & Development*, *99*(2), 167-177. https://doi.org/10.1002/jcad.12364

Renninger, K. A. & Su, S. (2012). *Interest and its development. In Oxford Handbook of Human Motivation*, Richard M. Ryan (Ed.). Oxford University Press, 167–187. https://psycnet.apa.org/doi/10.1093/oxfordhb/9780195399820.013.0011

Russell, R. (1996). *Science and mathematics education reform: What do parents need to know to get involved?* American Association for the Advancement of Science (AAAS). Washington, DC. ERIC Documentation Reproduction Services (ED400182)

Rutherford, B., Anderson, B., & Billig, S. (1995). *Studies of educational reform: Parent and community involvement in education*. RMC Research Corporation. U.S. Department of Education, Office of Educational Research and Improvement.

Shymansky, J., Yore, L., & Hand, B. (2010). *Empowering families in hands-on science programs.* Paper presented at the International Conference of the Association for Educating Teachers in Science, Austin, Texas, January 14-17, 1999. U.S. Department of Education. https://doi.org/10.1111/j.1949-8594.2000.tb17319.x

Stillman, J., Anderson, L., & Struthers, K. (2014). Returning to reciprocity: Using dialogue journals to teach and learn. *Language Arts*, *91*(3), 146–160. http://www.jstor.org/stable/24575021

Silander, M., Grindal, T., Hupert, N., Garcia, E., Anderson, K., Vahey, P., & Pasnik, S. (2018). What parents talk about when they talk about learning: A national survey about young children and science. *Education Development Center, Inc.*

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed-methods research: Integrating quantitative and qualitative approaches in social behavior and sciences.* Sage. https://doi.org/10.1177/15586898211018086

Walker, J., Hoover-Dempsey, K., Whetsel, D., & Green, C. (October, 2004). *Parental involvement in homework: A review of current research and its implications for teachers, after school program staff and parent leaders.* Harvard Family Research Project. Cambridge, MA.

Wang, M. C., Haertel, G. D., & Walberberg, H. J. (1997) What helps students learn? *Education Leadership*, *52*(4). 74-79.

Wen, C. T., Liu, C. C., Chang, H. Y., Chang, C. J., Chang, M. H., Chiang, S. H. F., & Hwang, F. K. (2020). Students' guided inquiry with simulation and its relation to school science achievement and scientific literacy. C*omputers & Education, 149,* 103830. https://doi.org/10.1016/j.compedu.2020.103830

Yan, Z. (2020). Self-assessment in the process of self-regulated learning and its relationship with academic achievement. *Assessment & Evaluation in Higher Education, 45*(2), 224-238. https://doi.org/10.1080/02602938.2019.1629390

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