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Parent Involvement and Its Influence on Children's STEM Learning: A Review of the Research

Julie Thomas

Juliana Utley

Soo-Young Hong

Hunkar Korkmaz

Gwen Nugent

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A growing understanding that parents and teachers can effectively collaborate to help children succeed in school has led worldwide policymakers and school leaders to begin deliberate actions to increase parents' participation in school life (e.g., Epstein, 2018; Raikes & Love, 2002). For example, the Chilean Education Minister recently encouraged contracts between parents, schools, and the state to increase parental involvement (Borgonovi & Montt, 2012). The Australian government has formed a Research Alliance for Children and Youth (Australian Government Department of Education and Training, 2018) to develop and promote understanding of parent involvement (i.e., what it is, why it matters, how it influences learning) and to build evidence about what works. From a sociological perspective, a school's organizational boundaries are permeable (Ballantine & Spade, 2008), thus the outside environment (which includes parental culture, values, and knowledge) can mediate student achievement. Therefore, a considerable body of research demonstrates the cultural capital parents wield as they (intentionally or unintentionally) hand down familial norms, skills, and habits (Ceglie & Setlage, 2016).

The purpose of this chapter is to discern the international scope of research that describes parent involvement as it relates to children's STEM learning. However, this noble intent was offset somewhat by (a) the limited research on parent involvement in STEM (though considerable research has been done on parent involvement in science and mathematics independently) and (b) the limited international research on parent involvement in STEM as an integrated focus. Authors identified these limitations as a chance to broadly recognize cultural context as both a U.S. and an international concern and to generate recommendations for future opportunities in the burgeoning field of research on parent

involvement. While seeking to develop an international perspective, this international team of authors continuously generated a list of search terms, online databases, and references that came to include more than 300 articles, reports, books, and dissertations relevant to this research review. Through a system of independent reading and team discussions, authors distilled current research findings within three broad categories: (1) academic advantages related to parent involvement, (2) culture as a context for parent involvement, and (3) teacher/school perspectives on parent involvement. In closing, authors pointed to gaps in the knowledge of parent involvement in STEM education and opportunities for future research.

Academic Advantages of Parent Involvement

Parent involvement in education is widely believed to influence student outcomes. A plethora·of research shows that children demonstrate a variety of achievement-related outcomes when parents are actively involved with their child's education. In the case of general socialization benefits, research has shown parent involvement impacts children's:

- social, emotional, and character development (e.g., Green, Walker, Hoover-Dempsey, & Sandler, 2007; Lewin & Luckin, 2010; Selwyn, Banaji, Hadjithoma-Garstka, & Clark, 2011; Schnee & Bose, 2010); and
- increased attendance, reduced suspensions, and reduced high school dropouts (e.g., Christenson & Sheridan, 2001; Epstein & Sheldon, 2002; Sheldon, 2007).

With regard to general school achievement, research has shown parent involvement positively influences children's:

- attitude toward school (Aunola, Stattin, & Nurmi, 2000; Christenson & Sheridan, 2001; Eccles, 2007; Epstein & Sheldon, 2002; Frome & Eccles, 1998; Gonzalez-DeHass, Willems, & Holbein, 2005; Grolnick, Friendly, & Bellas, 2009; Sheldon, 2007; Vauras, Salonen, Lehtinen, & Lepola, 2001);
- academic motivation (Eccles, 2007; Fan & Williams, 2010; Grolnick, Kurowski, Dunlap, & Hevey, 2000; Häfner et al., 2018; Hoover-Dempsey et al., 2001; West, 2000);
- pursuit of difficult tasks (Gonzales-DeHass, Willems, & Holbein, 2005);
- self-efficacy (Fan & Williams, 2010; McGrath & Repetti, 2000); and
- academic performance (Domina, 2005; Epstein & Sheldon, 2002; Galindo & Sheldon, 2012; Häfner et al., 2018; Jeynes, 2010; Kim & Sheridan, 2015; Ma, Siu, & Tse, 2018; McNeal, 1999; Organization for Economic Cooperation and Development, 2017; Park & Holloway, 2017; Wilder, 2014).

Considering the specific skills in STEM content areas, research has shown parent invvolvement positively affects children's:

- quantitative skills (Evans, 2004; Yan & Lin, 2005); and
- problem-solving skills (Cai, 2003; Evans, 2004).

Though few studies have analyzed the impact of parent involvement in a cross-national context (Borgonovi & Montt, 2012), some international comparisons of the impact of parent involvement are included in the Program for International Student Assessment (PISA) results. PISA, the highest-profile international comparative study of 15-year-olds, has assessed parental involvement in selected Organization for Economic Cooperation and Development (OECD) countries since 2006. PISA's 2012 assessment (distributed across 13 countries and economies to include Croatia, China [Hong Kong and Macao], Denmark, Germany, Hungary, Italy, New Zealand, Portugal, Panama, and Qatar) focused on mathematics literacy. Some of the parent survey questions explored parent involvement as it related to student success, variations across school systems, and variations across different culture/socioeconomic groups. These results showed parents' expectations were strongly and positively associated with students' mathematics performance and positive dispositions toward learning (OECD, 2014). Borgonovi and Montt (2012) linked these data to student achievement and demographics and reasoned that, though the rates of parent involvement varied greatly in socioeconomically disadvantaged households, some (more successful students) were better equipped to benefit from parent involvement.

PISA's 2015 assessment focused on students' proficiency in science. In this year, the parent and student survey queried parents' participation in science-related activities with their child at age 10 (e.g., reading books on scientific discoveries, watching science programs on TV, and experimenting with a science kit). While this review of parents' early support of science activities did not determine any causal link, the data did reveal a close relationship between parents' early engagement in science activities and students' attitudes toward science (i.e., science enjoyment and science self-efficacy) at age 15 (OCED, 2017). Thus, it is possible these early learning experiences were the result of an early interest to begin with; it is also possible these parent-led activities led to a deeper enjoyment of science and helped these students become more confident about learning science.

In addition to student outcomes, researchers have examined parent and student perceptions of parent involvement in at-home or out-of-school activities. For example, when parents perceive that academic achievement is correlated to homework completion, they are more likely to get involved in children's homework (Mora & Escardibul, 2018). Some researchers have found children feel that they do better at school when parents assist them with their homework (Balli, 1998; Dumont et al., 2012) and teenagers explained parents' emotional support was valued and important their perception of the future (Irwin, 2009). In this case, the data determined parents' direct involvement in students' science education (e.g., helping with science homework or gathering science-related materials) was negatively related to students' science achievement (OECD, 2017). Given that PISA students are early adolescents, these results are consistent with others' findings about parents' support with homework (Hill & Tyson, 2009; Hoover-Demsey et al., 2001; Sibley & Dearing, 2014; Xu, Benson, Mudrey-Camino, & Steiner, 2010). However, this PISA 2015 data may also reflect causal differemces in parental involvement with children who are performing well and those who are performing poorly in science (OCED, 2017).

Lastly, as parents become more involved in their children's education, research has shown parent involvement positively influences teachers and the school at large:

- teachers gain confidence in teaching children (Epstein, 1987; Hoover-Dempsey, Bassler, & Brissie, 1987);
- student-teacher relationships are enhanced (Hill & Craft, 2003; Stevenson & Baker, 1987);
- administrators strengthen community relations (Henderson, Marburger, & Ooms, 1986; Heystek, 2003);
- curricula is transformed as teachers build on community funds of knowledge (Moll, 1992; Peressini, 1997); and
- schools become more collaborative and caring when they work with the community at large (Feuerstein, 2000; Henry, 1996; Zhao & Akiba, 2009).

Culture as a Macrosystemic Context for Parent Involvement in a Child's STEM Learning

Learning involves socially and culturally mediated processes (Vygotsky, 1978). Thus, to understand how interactions between parents and schools influence children's achievement in any country, the cultural variations in how parents define and express their expectations for children's learning need to be examined (McKenna & Millen, 2013). Understanding how parents see their role in a child's STEM-related learning can help schools engage parents effectively and meaningfully. To this end, reseachers have begun to notice variations within and between cultures in terms of how the parents' role is understood and manifested. Thus, this section reports on recent research related to (a) the ways cultural beliefs are embedded in parents' beliefs about involvement in their child's education and (b) how the association between parental involvement and children's STEM-related performance differ across social and cultural groups.

Culture and Parental Beliefs
Culture is a macrosystemic context of human development frequently considered to play an indirect role in an individual's learning and development (Bronfenbrenner & Morris, 2006). Given that cultural expectations are embedded consistently in children's everyday interactions and activities, culture has been regarded as one of the most important factors in children's development (Velez-Agosto, Soto-Crespo, Vizcarrondo-Oppenheimer, Vega-Molina, & Coll, 2017). Cultural context situates the way parents form expectations about their child's achievement in STEM-related areas. Importantly, these parental expectations help to form children's self-efficacy and achievement across all ages. By way of example, parents' educational expectations and aspirations have been highly associated with elementary achievement in science (Thomas & Strunk, 2017) and high school achievement in mathematics (Yan & Lin, 2005). As well, parents' beliefs and expectations have been shown to predict elementary science achievement (Thomas & Strunk, 2017) as well as elementary and middle school mathematics achievement (Entwisle & Alexander, 1996; Gill & Reynolds, 1999; Halle, Kurtz-Costes, & Mahoney, 1997; Holloway, 1986).

Parents' communication of the value of education, linking education to future success, and providing support for their child's academic and career expectations are important (Hill & Tyson, 2009; Jeynes, 2005). However, a child's ethnicity is associated with different kinds of parent involvement in their STEM-related achievement. For example, in the case of older children, social capital has been an important predictor of achievement for White children, whereas parent-teen relationships are a more critical factor influencing the learning of children from minority groups (Yan & Lin, 2005). Parental beliefs about their own personal ability to help their child be successful in STEM-related activities is another key variable in parent involvement. In fact, parents tend to avoid contact with schools when they believe they lack the ability to help their child be successful at school (Hoover-Dempsey & Sandler, 1997). Furthermore, when parents believe they lack the necessary content knowledge to help their child learn mathematics or science, a condition that becomes more prevalent as the child moves into secondary school, parents avoid supporting STEM experiences outside of school (Eccles & Harold, 1993; Knapp, Landers, Lian, & Jefferson, 2017). Parents' beliefs about their child's intelligence also influences parental involvement (Hoover-Dempsey & Sandler, 1997). For instance, a mother's beliefs about her elementary child's capability in mathematics positively influences her involverment with the child's education and has been shown to predict the child's perceptions of his or her own abilities (Simpkins, Fredricks, & Eccles, 2012).

Culture and Socioeconomic Status
Research has shown that the family's socioeconomic status (SES) is related to children's learning outcomes. Even within the same cultural group, parents with high SES seem to provide direct support for a more extended period as compared with those with low SES (Liang, 2013). When controlling for SES, parents' motivational beliefs and other perceived contextual variables explained a significant amount of variance in parents' involvement in their child's education (Davis-Kean, 2005; Green et al., 2007). Prior research has shown that parents of certain ethnic backgrounds are more likely to be involved in chldren's education. For example, liow parents are connected to their own culture of origin and whether parents and teachers share the same ethnic backgrounds are both associated with their level of engagement (Calzada et al., 2015). Importantly, incongruence in U.S. and Latino parents' cultural beliefs and expectations about parent involvement seems to provide potential explanation for the low academic performance of Latino children (Hill & Torres, 2010). On the other hand, schools in both the United States and Japan value the concept of "parents as partners of teachers and other parents"·(Jabar, 2010). Chinese American culture also emphasizes parents' important role in their child's education (Chen & Luster, 2010). In this culture, parents' high aspirations for their child's education is evident in the ways these parents make careful decisions about which school districts their children attend (Liang, 2013).

PISA 2015 parent survey data from Latin American countries (i.e., Chile, the Dominican Republic, and Mexico) suggested inflexible work schedules, childcare services, and problems with transportation hindered parents' participation in school activities (OCED, 2017). In addition, parents largely reported that they did not know how they could participate in school activities, nor did they expect their participation was relevant to their child's

development/school success. These data, about barriers to parents' participation in their child's school activities, help illuminate the various ways parent-school communications are constrained.

Teacher/School Perspective on Parent Involvement

Research shows the importance of schools and families working together to ensure student success. Parents' and teachers' interactional experiences, acoss home and school, form the foundation for educational pathways lasting through adulthood. Together, parents and teachers arrange the large contextual influence regulating children's learning and development. The perceptions of parents, teachers, and principals toward family-school partnerships are instrumental in developing a family-friendly school culture that supports a partnership approach. Gordon and Lewis (2009) found teachers' perceptions of the level of parents' involvement in their child's learning, as well as their own beliefs in shared partnerships, were related to a child's school achievement. In addition, principals' perceptions and support of family-school partnerships have been linked to the successful development and sustainability of parental involvement (e.g., Payne, 2008; Payne & Eckert, 2010). At an even higher level, district structures and policies substantially influence school-based implementation of family-school programs and activities. For example, Sheldon (2016) found that schools reporting greater support from the district office tended to have stronger, more sustainable partnership programs. Importantly, national educational policy can influence collaboration between schools and parents. In Sweden, for example, the democratic mission of the school system leads to inclusion of parents in formal school decision-making (Dahlstedt, 2009). The following sections include research related to the features of impactful partnership practices aud teachers' limited opportunities to learn about how to initiate and manage parent involvement.

Impactful Parent Involvement
Not all parent involvement seems to influence children's learning. For example, rescearch on classroom volunteerism, school event attendance, and parent-teacher conference attendance (e.g., Hill & Tyson, 2009; McWayne, Hampton, Fantuzzo, Cohen, & Sekino, 2004) has not determined a positive relationship between children's academic achievement and parents' involvement. Some research, however, has determined that parent involvement in school activities can lead to positive social benefits. For example, Bouffard and Weiss (2008) discovered that the engagement of parents in learning in the·home has a large effect on children's learning. These parent engagement activities include supporting in-school learning, fostering children's expectancy of success in school and their future, and providing needed resources to support both in-school and out-of-school learning (Epstein, Sanders, Sheldon, Simon, & Salinas, 2009). Research has shown that learning activities and parent-teen discussions conducted at home specifically predict higher student mathematics achievement in middle and high schools (Ho & Willms, 1996; Keith et al., 1993). Other research, on the relationship of partnership practices and the percentage of children scoring satisfactorily on mathematics achievement tests, showed significant correlations related to homework that required parent-child interactions or use of take-home mathematics materials

(Sheldon & Epstein, 2005). This research determined that the *use* of the activity was not enough; it was the·*quality* of implementation that was associated with student mathematics achievement. Similar findings have been linked to science outcomes; providing parents with specific guidance (on how to be involved in science homework) improved their children's homework accuracy and led to improved science classroom performance (Van Voorhis, 2003).

Researchers have found that beneficial parental involvement may also take the form of supporting children's informal STEM activities (Hill & Tyson, 2009; McWayne et al., 2004) that include after-school STEM-focused programs (Dearing, Sibley, & Nguyen, 2015; Nugent, Barker, Grandgenett, & Welch, 2016). In addition to influencing both STEM learning and STEM attitudes, these opportunities encourage children to seek out additional opportunities and to further explore STEM topics. One parent intervention, which helped parents encourage their children to take STEM courses in high school, showed a significant effect on high school STEM preparation and predicted subsequent STEM career pursuit (Rozek, Svoboda, Harackiewica, Hulleman, & Hyde, 2016). Successful implementation of this strategy required parental knowledge of relevant school and community resources and STEM career and college pathways. Some researchers have explored the relative differences of parents' funds of knowledge (related to education pathways beyond high school) as they varied across ethnic and socioeconomic differences (Hill et al., 2004; Lareau, 2003; Lareau & Horvat, 1999). Hill (2015) found middle-class parents held advanced knowledge about how schools function and about the pathway from high school to college (Hill, 2015).

Teacher Preparation

Despite research demonstrating that family-school partnerships are critical to student behavioral and academic success, many teachers do not receive training in ways to effectively engage parents—either internationally (e.g., Guo & Wu, 2018) or in the United States (e.g., Stormshak, Dishion, Light, & Yasui, 2005; Stormshak, Connell, & Véronneau, 2011). It seems that novice and experienced teachers alike need to learn how to engage families from different cultures (LaRocque, Kleima, & Darling, 2011). Gottfredson and Gottfredson (2002) argued that teachers need encouragement, scaffolding, and feedback about their interactions with parents. One successful intervention for U.S. preservice mathematics teachers involved school-family nights, showing positive effects on preservice teachers' comfort level and perceptions in working with parents (Boefferding, Kastberg, & Hoffman, 2016). Successful programs in other countries have involved co-teaching between parents, teachers, and preservice teachers in Australia (Willis, 2018) and a participatory approach by preservice teachers in Canada using ongoing dialogue with parents of ELL learners (Shin & Robertson, 2018).

Conclusion and Opportunities for Future Research

Importantly, we set out to review international research defining how parent involvement influences children's STEM learning. Instead, the available research led us to focus this research review on parent involvement and its impact on children's success in science and

mathematics. In this, we chose to explore the importance of cultural context (as both a U.S. and an international concern) and to generate research recommendations on parent involvement in STEM learning environments. Similar to Hoover-Dempsey and Sandler's (1997) earlier landmark review of parent involvement, further research on the evolution of parents' role construction related to school success can aid the design and measurement of school efforts to create an affirmative construct for parent involvement. This literature review revealed several areas for future research related to parent involvement in STEM classrooms.

To begin, researchers might help advance understanding about parent experiences (e.g., direct experience, vicarious experience, persuasion, and emotional arousal) that contribute to self-efficacy (Bandura, Barbaranelli, Caprara, & Pastoreli, 1996) relative to parents' involvement in school. In the case of STEM classrooms, a researcher could explore alignment between parents' and children's STEM efficacies: how and when are children's aspirations related to parents' attitudes and self-concepts? More research on parent involvement in STEM classrooms can help us to understand the complex interplay between the classroom context and varying levels of parents' self-efficacy across the STEM content areas as it is related to children's STEM achievement and STEM career aspirations.

Researchers might also consider the ways in which a STEM learning environment offers affordances that increase parent involvement. Here, researchers might explore programs designed to help parents overcome challenges posed by contextual variables (e.g., time, work schedules) and work with families to discern innovative involvement practices. Future research might examine how socioeconomic variables moderate the relationship between STEM learning environments and parents' involvement decisions. What research model could help deliniate the differences between those parents who do participate in their child's school life and those parents who do not? How and when does a STEM learning environment constrain or expand parent involvement? What communication strategies enable parents' sense of efficacy for helping children succeed and lead to increasing effective parent involvement? What policies and practices enhance parental engagement across race, culture, and socioeconomic background?

Given the corpus of research displaying the critical balance between the family-school relationship and student achievement, teacher education programs might increase teachers' (preservice and in-service) opportunity to learn how to maximize parent involvement in schools. How might teachers learn to take an active role in enhancing parents' positive engagement at home and in school (e.g., exploring take-home activities or communication tools)? Research focused on this proposition would enhance our understanding about how to prepare teachers to build and maintain family relationships and guide development of school policies as well.

Lastly, researchers might explore responsive family communications that extend beyond the traditional activities (e.g., newletters). How might schools strategically plan activities to promote purposeful, curriculum-related STEM interactions between student and family members? As Harris and Goodall (2008) explained, parental engagement cannot be a bolt-on extra—it must be a central priority. In this, parents need to be seen as an integral part of children's learning. How do school policies define parents' roles? How might unique options (e.g., teacher-release time, a parent-community liaison to facilitate increased parent-

school interactions, or an editor to help create and distribute regular communications from teachers to parents) improve school-home communications about learning goals, activities, and focused suggestions for parental help?

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