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Informal Elementary Science: Repertoires of Parental Support

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Abstract: Children's early exposure and participation with science activities may help reduce underrepresentation issues that are often seen later in some disciplines of science, technology, engineering, and mathematics (STEM) majors and occupations. To help understand these trends, this study investigated the repertoire of parental support during hands-on science activities with their children with regards to ethnicity (Latiné families of predominantly Mexican origin and non-Latiné, primarily White, families) and gender. It was informed by work that examines gender, race, and ethnicity differences in STEM participation. Participants were 153 girls and boys, aged 8 to 12 years, and their mothers and fathers in the Southwestern United States. Each parent–child dyad's behaviors during hands-on science activities together were examined. After controlling for family annual income and parental level of education, there were several variations by ethnicity and gender in parents' support of their children (e.g., help and encouragement), children's exploration of the activities, children's talkativeness, and the amount of time they engaged in the activities. Suggestions for expanding STEM education programs to be more inclusive of underrepresented communities are discussed.

Keywords: science education; elementary; parents; families; culturally diverse students; Latiné; gender; informal education; out of school

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1. Introduction

Underrepresentation has been documented in some disciplines of science, technology, engineering and math (STEM) [1]. This trend has been framed by work that examines gender, race, and ethnicity differences in STEM participation [2–4]. There is clear evidence that parents play a critical role in the development of their elementary school-age children's science-related interests and attitudes [5–8]. Previous research has also documented that students often begin to lose interest in science or have lower science self-concept by the middle-school years for numerous reasons. This has been noted for students overall, as well as for students from ethnic/racial minorities and girls in particular [2,9,10].

This study examined the behaviors of Latiné and non-Latiné middle elementary (4th grade) students and parents as they worked on hands-on science activities together in an informal STEM learning environment. Further, it sought to understand patterns in parent–child discourse and behaviors based on both ethnicity and gender. The findings will help identify parents' influences in the years leading up to the decline in some children's science-related interest, attitude, and self-concept with the purposes of (a) broadening parents' repertoire for practices used to support their children in science and (b) expanding educators' perspectives about what knowledge and experience counts when engaging Latiné students in science activities. Finally, it is critical for a study of this scope to acknowledge and recognize that schools often privilege parent–child interactions that may be more typical of White (non-Latiné), middle-class families [11,12].

This study was built upon previous work that acknowledged the strengths that all students and parents bring to informal science education settings [4,13]. Yosso's Community

Cultural Wealth framework (CCW) [4] questions whose cultural capital is privileged in schools and challenges us to expand our understanding of the cultural knowledge, skills, networks, and abilities that our Latiné students and families bring to schools. The CCW framework forms the basis for centering and valuing the lived experiences of students from minoritized groups. CCW identifies six types of capital that students possess: aspirational, linguistic, familial, social, navigational, and resistance capital. Familial capital, which Yosso describes as "those cultural knowledges nurtured among *familia* (kin) that carry a sense of community history, memory and cultural intuition" [4] (p. 79), is most directly relevant to our work. There may be multiple ways for parents to support their children's science learning and seek to create spaces where families feel welcomed and respected for the knowledge they bring into educational settings. It is important to recognize and honor the various ways in which families' community cultural wealth is expressed in educational spaces [14].

By volunteering to participate in this science research project, the families in the study demonstrated an interest in science. This is relevant to the concept of science capital (e.g., [15–17]), which is a subset of social capital that reflects students' science interest, identity, and self-efficacy. Based on their work in informal science education settings, such as in a program for youth at a museum, Habig, Gupta, and Adams [18] have recently expanded the concept of science capital to include science, technology, engineering, and math (i.e., STEM capital).

As described in the following literature review, our focus is on parents. Specifically, we examine how they provide guidance and encouragement stemming from their own community cultural wealth and expose their children to different experiences and opportunities, all of which help to develop their children's interests and attitudes.

1.1. Ethnicity and Gender in STEM

A student's self-concept, interests, self-efficacy, participation, and parental support in STEM are often affected by the student's ethnicity and gender; however, these two identities should not be considered in isolation [7,19–21]. Indeed, numerous recent studies have explored these identities of gender and ethnicity in STEM through an intersectional lens [7,19–21], as we did in this study. For this literature review, we include some past studies that included only ethnicity or gender differences, even if they did not tease out differences within both ethnic and gender groups (such as Latinas, Latinos, White (non-Latiné) women, and White (non-Latiné) men).

Many reasons have been identified for differences in science interest, motivational beliefs, and achievement between Latiné and non-Latiné students. They include individual and family characteristics (such as socio-economic status), psychological factors (such as self-efficacy), differential school resources and classroom environments (such as racial prejudice from teachers, less classroom resources, or larger class sizes), interest in science-related careers, and family influences (such as parental support) [12,22–24]. Student interest and achievement in science and math are related to student self-efficacy for Latiné students and students overall [5,25], and Moakler and Kim [26] suggest providing more positive learning experiences for underrepresented students to develop positive self-efficacy in science-related studies. Additionally, French et al. [19] indicated that attainment value, or the value of the topic to self/identity, was strongly related to performance in college-level chemistry for students from underrepresented racial/ethnic groups. Furthermore, self-perception of ability in STEM is critical for a student's identification with STEM careers for middle-school girls of color regardless of racial/ethnic group [21]. They also noted that a student's self-perception of ability depended on the quantity and quality of their experiences with science at home, at school, and through out-of-school experiences.

It is important to note that even when science achievement is controlled, Latiné students still show less interest in STEM fields as compared to their White or Asian peers who have the same assessment scores [12]. Furthermore, motivational beliefs of Latiné and White male and female high-school students have been examined [7]. White male students have reported the highest motivational beliefs and the most parental support behaviors whereas Latinas have reported the lowest motivational beliefs and least parental support. Instructional practices must also be considered because when 5th-grade Latiné students were taught science concepts using a constructivist, hands-on approach, they experienced more gains in content knowledge and interest in science compared to traditional instructional practices [27]. Therefore, we must consider socialization, school and community culture, and familial influences when examining student interest, self-identity with STEM careers, motivation, and achievement.

Parallel to the differences reported by ethnicity, girls are less likely than boys to demonstrate interest, motivation, and achievement in some STEM fields. Children's gender-stereotyped beliefs about science interest [10] and math ability and performance have been documented as early as grades K–5 [28,29]. Moreover, there is often a decline in girls' interest in science and math by the time they reach middle school as they are socialized according to science gender stereotypes [9,30,31]. Interestingly, high school girls' achievement in science and math is higher in single-sex schools as compared to mixed-sex schools, but they do not have more positive attitudes about these subjects in single-sex school environments [32]. At the college level, male students in chemistry courses had more confidence in their chemistry ability; however, female students put greater emphasis on the importance of the utility of chemistry in their lives [19]. Finally, countries with stronger overall "science = male" implicit stereotypes had larger performance gaps between boys and girls on 8th-grade science performance data from Trends in International Mathematics and Science Study (TIMSS) tests [33].

At the intersection of gender and ethnicity, there are some striking contrasts. Hsieh et al. [20] examined the science identity of 9th-grade students who aspired to attend college. They found that among students who would be first-generation learners, females expressed lower science identity than males in all racial/ethnic groups (White, Black, Latino) except Asians. Moreover, White females who would be first-generation students also expressed lower science identity than those who would be continuing-generation students, but this trend was not true for other racial/ethnic groups.

Similarly, when math motivational beliefs of high-school students were examined by race/ethnicity alone, Latiné and Black students reported low motivation. Also, female students of all racial/ethnic groups except Asians reported lower math motivation than their male peers. When examining both gender and race/ethnicity, the researchers found that only Latina and Black female students demonstrated significantly lower math motivation, and not their male counterparts [20], indicating that it is not enough to examine race/ethnicity or gender alone.

1.2. Parental Support in STEM through Ethnicity and Gender Lenses

Parental support is a significant and important factor for helping students to develop their math and science interests, self-efficacy, and expectations for the future [5,7,8,34]. Parents nurture their children's interests and encourage and motivate them to persist in science and math via many formal and informal mechanisms [35,36]. Parents may enroll their children or participate with them in out-of-school STEM activities, watch science television shows, or discuss current events related to STEM [7,37], or they may simply help their children by setting up a time and place to study and encourage their children to do their work [38]. In previous research including students ranging from 5th grade to early college, those who reported being encouraged by parents, teachers, and friends to pursue interests in science and math had better self-competence and were more likely to persist in STEM classes and majors [5,36,39]. Furthermore, appropriate forms of praise from parents and teachers can influence a child's self-efficacy on a task because a child believes they can succeed if they work hard enough at the skill or task [40,41]. Finally, parents who possess more positive beliefs about their children's math abilities are more likely to provide materials and work on math activities with their children [42].

Parental support influences all students. However, numerous studies that specifically focus on Latiné and Black students have also found positive relationships between parent STEM support and students' motivations, interest, and ability self-concept [7,34,43,44]. Family (parent and older sibling) support predicts STEM self-efficacy and ability self-concept for Mexican American 8th graders [25] and Latiné high-school students [43], but support from teachers does not. In a similar study with diverse (e.g., 31% Latiné) high-school students, Garriott et al. [5] found that parental support predicted several learning experience variables, particularly performance accomplishments, verbal persuasion, and vicarious influence.

Parental and family support in STEM also influences the STEM college pursuits of Latiné adolescents. In a study examining who encouraged high-school students to enroll in advanced courses, Witenko, Mireles-Rios, and Riols [45] found that Latiné and White students received most of their encouragement from their parents and guardians. Similarly, a study of Latiné adolescents entering college in STEM fields reported that their parents played a significant role in their decision to attend college by encouraging them to persist, having high performance expectations for them, and expecting them to be positive role models for siblings and peers [46]. In addition, older Latiné siblings are very helpful with regard to STEM success in school as they possess cultural and STEM capital that they pass down to their younger siblings [47], especially when their parents have taken limited high-school science classes [48]. Bueno et al. [49] documented the importance and examples of informal instrumental and socio-emotional familial support provided to low-income community college students from underrepresented groups (e.g., Latiné, Black, Indigenous, and first-generation learners) pursuing STEM degrees. Their examples of socio-emotional support included support through listening and validation, through affirmation and well-being, and through advice.

Due to a number of factors, parental support may not be uniform across all gender and racial/ethnic groups or within sub-groups that meet at these intersections. For example, the amount of support that parents provide may depend in part on how confident they feel in their ability to help children develop science skills. Survey results outlined in a report from the National Research Center on Latino Children and Families [50] demonstrated that Latiné parents feel less confident about helping their children with science as compared to non-Latiné White parents. Unfortunately, the overall study did not control for socio-economic status through measures such as family income or parent education, and so it is unclear whether these results are related to family ethnicity alone or also to socio-economic variables that may be related to ethnicity.

Parents help shape their children's ideas about STEM majors and careers [6] and gender roles in society at large [51–54]. Unfortunately, parents tend to support boys in their STEM interests and aspirations more than girls due to unconscious (or sometimes conscious) biases. For example, parents and teachers are more likely to overestimate their sons' math and spatial reasoning abilities and underestimate their daughters' abilities and to attribute boys' math successes to ability and girls' successes to hard work [55–57]. Additionally, Andre et al. [58] found that parents believed that science was more important for boys than girls and that boys were more competent than girls in scientific domains. Moreover, parents were less likely to encourage their daughters than their sons to pursue STEM degrees [59]. Thus, the gender of the child and the parent may influence the ways in which they encourage (or do not encourage) their children to participate and persist in STEM activities and courses [60,61]. Differential encouragement and support by parents can result in differences in children's interests, attitudes, behaviors, and self-efficacy in STEM [5]. Accordingly, it has been advocated for parents to support the development of their middle-school daughters' science experience at home, with school, and through out-of-school experiences [21]. This call to focus on middle-school girls is intended to address the disparate support they often experience in home and at school and is critical to help them develop a positive self-perception of their abilities in STEM and identification with STEM careers.

1.3. STEM Enrollment and Performance

Students in underrepresented and marginalized groups in STEM fields are fighting an uphill battle when it comes to STEM achievement. They often experience less support from educational institutions [12,22–24], and the instructional style for many STEM courses is not appealing to these students [27]. Additionally, parental support may be influenced by gender, race, and/or ethnicity either subconsciously or because some parents may feel less comfortable providing support and/or engaging with traditional educational institutions [5,50,60,61]. Not surprisingly, differences then exist in student enrollment and achievements according to race/ethnicity and gender in many upper-level high school and college STEM programs [27,62]. Differences in participation and performance in STEM by gender and ethnicity are evident beginning in students' K–12 educational experiences.

While this study focused on Latiné students, it is important to consider the participation and performance of students from underrepresented groups in addition to Latiné groups. With regard to standardized test performance in K–12 education, female students and students from traditionally underrepresented racial/ethnic groups, including Black, Hispanic, and American Indian/Alaska Native students, often score lower on the National Assessment of Educational Progress (NAEP) science tests throughout their K–12 careers [63]. While gaps are decreasing at some grade levels for some groups, progress has been slow. Gender differences for science overall do not show up until the 12th grade, with boys scoring slightly higher than girls. However, if we examine individual content areas, girls score higher than boys in the 4th grade in the life sciences while boys score higher in earth/space sciences in the 4th and 12th grades and in physical sciences in the 8th and 12th grades. Similarly, gaps persist in advanced placement (AP) enrollment and test taking [64] and performance [65] for students who identify with underrepresented groups. In addition, female students are less likely to take certain AP exams in science and math (such as physics, calculus, and computer science), which influences their pursuit of STEM degrees in college [66].

Latiné students and female students overall continue to experience cultural, social, and academic biases that influence their self-efficacy, aspirations, and educational performance in STEM. Among high-school students in the United States, there is a 36-point difference between the percentage of girls and boys who aspire to STEM careers. Only about 28% of Latinas and 32% of girls from historically overrepresented groups (ORGs = White and Asian) aspire to STEM careers, compared to 64% of Latino and 68% of ORG boys [67]. In university settings, Latiné students (who make up 17% of the U.S. college population) earn 7% of physical sciences and 9% of biosciences undergraduate degrees [1], with Latinas earning less than half of the STEM degrees awarded to Latiné students.

Furthermore, according to the U.S. Bureau of Labor Statistics [68] Latiné employees remain significantly underrepresented in many science occupations. For example, while Hispanic or Latino employees represent 18.5% of the total workforce, they represent only 3.5% of those in biological sciences, 9.1% in chemistry and material sciences, and 10.3% in the applied physical science occupations of architecture and engineering. Women also remain underrepresented in some science occupations. The U.S. Bureau of Labor Statistics [68] indicates that the gender gap has narrowed in some fields (e.g., biological science) but not all of them. They report that women represent 46.8% of the total workforce, with women's representation amounting to 57.9% in biological science, 46.3% in chemistry and material sciences, and 16.1% in architecture and engineering.

1.4. Studies with Families in Informal Science Contexts

Research conducted previously has investigated children's science learning with their parents in various informal settings. For example, Fender and Crowley [69] observed parents with their 3-to-8-year-old children at a science museum exhibit about how zoetropes work (by producing an illusion of motion, as in animation). They found that children whose parents participated in the exhibit with them remained engaged longer and learned more about how zoetropes worked. Further, children whose parents provided explanations were more likely to understand the use of the zoetrope in animation. In another study of young children [70], parents of 4-to-6-year-olds were observed at an interactive volume (i.e., conservation) museum exhibit. Parents who had received guided instruction on how to discuss the topic asked more "how" and "why" questions than the other parents, which can be very important tools to help develop inquiry skills. Zimmerman, Reeve, and Bell [71] followed families with children between the ages of 5 and 12 years who regularly attended the science museum in which their study was situated and noted that both children as well as adults can and often do take the lead on sharing science content in science discussions. These studies' results indicate that parental involvement in informal science contexts is critical for developing in-depth engagement, deeper learning, and developing inquiry skills.

Other studies in informal science settings have investigated parent–child interactions as a function of child gender and/or parent gender. For example, Short-Meyerson, Sandrin, and Edwards [72] examined the interactions of 2nd and 4th grade children and their parents (mothers and fathers) while solving hands-on science problems together. They found that mothers used questioning more than fathers and girls were asked more questions than boys. Although parents used surprisingly few statements of encouragement overall, they used encouragement more with their sons than with their daughters.

Additionally, observations have been made of families of 6th- and 8th-grade children performing science and non-science tasks [73]. Videotaped sessions were coded for "cognitively demanding" speech (which included conceptual questions, causal explanations, and scientific vocabulary). The researchers found that fathers used more cognitively demanding speech than mothers.

Shirefley et al. [74] examined conversations of European–American and Latiné parents with their preschoolers while they read a science storybook together. They explored the proportion of parents' science talk as a function of parental level of education. They found that among the European–American families only, parents with 12–16 years of education used more science talk with their sons than with their daughters. However, there was no such difference for parents with 16 or more years of education.

Furthermore, in a study on the conversations of Mexican descent families of 3-to-9-year-olds, the researchers investigated two contexts: a visit to a children's museum, which involved open-ended interactions, and a sink–float science activity (similar to one of the activities in our study) at home [75]. They found that during museum visits, parents of Latinas displayed more collaborative behaviors than parents of Latinos whereas during at-home activities, parents of Latinos displayed more collaborative behaviors than parents of Latinas.

1.5. The Present Study

Our study focused on the influence of parents on their elementary school-age children's problem solving in STEM. It included groups of Latiné and non-Latiné families that were closely balanced in terms of parent and child genders. The study examined parent and child interactions as the parent–child dyads worked on hands-on science activities together, including both life science and physical science topics, and focused on verbal interactions.

The research questions guiding our work were as follows:

During hands-on science activities, (1) how did the parents support their children's science learning? The specific parental behaviors we examined were providing help, providing encouragement, questioning, and talkativeness. (2) How did the children engage with the activities and interact with their parents as they worked on the activities together? The specific child behaviors we examined were exploration, questioning, the amount of time spent engaged in the activity, and talkativeness. (3) Did these vary by ethnicity (Latiné, non-Latiné), parent gender, and/or child gender?

2. Materials and Methods

2.1. Participants

Participants were 153 fourth-grade children, each with their parent, guardian, or other adult relative. We will refer to all adult parental figures in our study as parents (mothers or fathers) in this paper for simplicity as the majority of the parental figures were parents or stepparents. We learned demographic information about the families from an extensive 43-item parent questionnaire, which was developed for this study based on constructs and categories employed by the U.S. Census and National Science Foundation (NSF) [1], administered at the end of the session. The children ranged in age from 8.87 years to 12.32 years (M = 9.89, SD = 0.55). The ages of the boys and girls were not significantly different, nor were the ages of the Latiné and non-Latiné children. The parents ranged in age from 23 to 61 years (M = 39.12, SD = 6.77), with mothers and fathers not significantly different from one another. However, the Latiné parents were younger than the non-Latiné parents (p = 0.003), with mean ages of 36.96 (SD = 6.02) and 40.29 (SD = 6.96) years, respectively. Efforts were made to balance the sample in terms of parent gender, child gender, and ethnicity (Latiné, non-Latiné) using targeted fliers to recruit dyads of specific combinations, such as Latiné dads and daughters (See Table 1).

Table 1. Number of dyads by gender and ethnicity.

Dyad Gender	Both Latiné	Both Non-Latiné	Non-Latiné Parent/Guardian and Latiné Child	Unspecified Ethnicity	Total
Father–son	13	16	5	1	35
Father–daughter	12	16	4	0	32
Mother–son	14	21	3	4	42
Mother–daughter	23	17	3	1	44
Total	62	70	15	6	153

Forty-one, or more than 90%, of the Latiné parents self-identified as Mexican, Mexican American, or Chicano and one each self-identified as Guatemalan, Spanish, El Salvadoran, and Dominican.

Additional demographic information from the parental questionnaire included the family's socio-economic status (SES), as indicated by the participating parent's level of education and the family's level of annual income. The item about parent education included six levels of education on the following scale: 0 = "less than high school", 1 = "some high school", 2 = "high school degree or GED", 3 = "some college", 4 = "college degree", and 5= "graduate or professional degree (such as M.S., M.D., etc.)". Mothers (M = 3.01, SD = 1.45) and fathers (M = 3.23, SD = 1.34) tended to have some college experience. Latiné parents reported that on average they had a high school degree or GED (M = 2.24, SD = 1.37) and non-Latiné parents reported that they had some college experience or a college degree (M = 3.51, SD = 1.22). Parents indicated their family's annual level of income in USD 10,000 increments from "less than USD10,000" to "USD110,000 or more". The mean annual level of income for the Latiné families was 2.83 (SD = 2.41), indicating an approximate average income of USD 28,000, and it was 5.98 (SD = 3.12) for the non-Latiné families, indicating an approximate average income of USD 60,000. In the analyses, annual income and parent level of education were included as blocking variables (described in Section 2.2).

Language preferences were also indicated on the parental questionnaire. The families spoke a variety of languages as their first language, with English and Spanish representing the vast majority of families. Of the Latiné parent–child dyads, 30 parents (40%) indicated that they spoke only or mostly Spanish at home while none of the parents in the non-Latiné dyads indicated that they predominantly spoke a language besides English at home. When the children were asked about language, 22 children (29%) from Latiné dyads indicated that they spoke only or mostly Spanish at home. Of the non-Latiné children, five children (7%) indicated that they also spoke a language besides English at home, although they were not asked whether this was their dominant language. The non-Latiné families were also not homogenous; however, 77, or 85%, of the non-Latiné parents identified as Caucasian or mixed-race (Caucasian and African American, Native American, or Asian). Therefore, for this paper, 'Latiné' is primarily used when referring to parents and children of Mexican descent and 'non-Latiné' is primarily used when referring to Caucasian parents and children.

The parent–child dyads were recruited using Spanish and English language fliers that were sent home with students through partnering school districts, posted at partnering libraries and community centers, and made available to parents at summer camps sponsored by the local YMCA, Boys & Girls Clubs, and local school districts in a large city in the Southwestern United States. Families were scheduled to come in one at a time to participate in sessions hosted at local libraries, neighborhood schools, or community centers or at a local university campus. In order to thank them for their participation, each family was offered their choice of a USD 50 gift card to a variety of department stores and restaurants. As per IRB and human subjects protocol, all families were assigned a random identification number to protect their anonymity and they signed a consent form prior to participation.

2.2. Procedure

All materials and instructions were provided in both English and Spanish, and bilingual (English and Spanish) research assistants hosted all sessions with bilingual or Spanish-speaking families. Following a brief warm-up game intended to help them feel comfortable in front of a camera and a researcher, each parent–child dyad completed six hands-on science activities together. Each activity included written instructions, materials needed to complete the activity, and an answer sheet on which to write a response. Three of the activities were physical science topics (completing an electric circuit, predicting whether objects would sink or float, and separating iron filings from other materials) and three were life science topics (predicting which areas of the tongue would be most sensitive to different flavors, determining the best locations to grow plants, and predicting heart rate during exercise). The six activities were presented to each family in a predetermined random order. Each parent–child dyad could spend as much time as they needed on each activity, and the time they spent ranged from approximately 4 min to 9 min. The parent–child interactions during these activities were video- and audio-recorded. After the hands-on science activities, the parent completed an extensive questionnaire to obtain demographic information, such as the child's and parent's ages, the child's and parent's ethnicities, the parent's level of education, and the family's annual income.

Transcription: The video and audio recordings from each activity session were transcribed by undergraduate and graduate students based on the Systematic Analysis of Language Transcript (SALT) [76] conventions and program. Use of SALT (Version 9) software involves typing predetermined codes into the transcript and then having the program tally the number of each code for individual parents and children. In addition to transcribing dialogue, the transcribers made notes about nonverbal behaviors to aid in interpreting the verbalizations. All Spanish content was translated into English for coding.

Coding of dependent measures: Appendix A contains descriptions of the dependent measures. Two graduate students were trained by the first author to code the parent–child interactions (described below). While watching the video-recorded interactions and following along on the transcripts, they coded for eight dependent measures (i.e., four parent behaviors and four child behaviors), which were based on previous work [69,72,77,78]. The parent behaviors were (a) helping behaviors by the parent, (b) questioning by the parent, (c) encouragement from the parent, and (d) number of parent utterances. The child behaviors were (a) exploration of the activity, (b) questioning by the child, (c) amount of time spent engaged in the activity, and (d) number of child utterances. Each of the behaviors was coded and quantified for all six activities together (i.e., the total for the session).

Reliability: The number of parent utterances, number of child utterances, and amount of time spent engaged in the activity were calculated using the SALT program such that inter-rater reliability was not needed for these dependent measures. Inter-rater reliability of coding of the remaining dependent measures described above was checked in two phases. First, for training, the primary rater (the first author) coded six of the sessions. Then, the two coders coded the same six sessions, and inter-coder agreement was calculated as a percent agreement for each dependent measure. Discrepancies were resolved through discussion and revisions to the coding schemes were made as appropriate. Then, for the second phase, using the revised coding schemes, 20% of the parent–child sessions were coded by both coders and percent agreement was calculated for each dependent measure. Percent agreement of at least 86% was achieved for all codes, with a range of 86%–99% (Help = 86.23%, Encouragement = 98.96%, Parent Questions = 86.41%, Child Questions = 99.41%, Exploration = 93.65%).

Statistical analyses used: Behavioral data from the parent–child interactions as they completed the six hands-on science activities were examined for the dependent measures described above. For each dependent measure, Multivariate Analysis of Variance (MANOVAs) or Generalized Linear Models (GLMs) were used to analyze whether the dependent measures varied by ethnicity (Latiné vs. non-Latiné), parent gender, or child gender. If a distribution was skewed, square-root transformations were used to normalize the distribution (i.e., to reduce the effect of outliers).

Each dependent measure was examined for the entire sample, and also to determine the effects of gender and ethnicity separately. The socio-economic status (SES) indicators of family's annual income and the parent's level of education were included in the models as covariates (i.e., blocking variables). Income did not explain any of the associations. Education explained a few of the associations, but the impact of the parents' level of education was removed by including it as a covariate. Associations persisted for the behaviors below even after accounting for education.

3. Results

Findings are reported for all six activities together (with parent behaviors first, followed by child behaviors). For each behavior, this includes findings with regard to parent ethnicity, child ethnicity, parent gender, and child gender. It also includes ethnicity results for girls and boys separately (i.e., non-Latina compared to Latina girls and non-Latino compared to Latino boys). Only p-values < 0.05 are reported.

3.1. Parent Behaviors

3.1.1. Helping Behaviors by the Parent

In general, parents offered their children substantial amounts of various types of help. These included (1) stating an observation about the problem, (2) providing an explanation, and (3) directing or telling the child what to do (e.g., "Connect these wires like this"). Mothers ($M = 3.10$, $SD = 1.17$) provided more help by stating an observation than fathers ($M = 2.64$, $SD = 1.15$), $p = 0.019$. Parental help did not vary as a function of ethnicity or child gender.

3.1.2. Encouragement from the Parent

Overall, parents offered little encouragement to their children. Of the encouragement offered, parents provided both general and specific encouragement, including encouraging comments to their children to keep working and not give up. The proportion of parental encouragement varied by ethnicity. Non-Latiné parents ($M = 2.78$, $SD = 2.87$) provided more encouragement than Latiné parents ($M = 1.34$, $SD = 2.22$), $p = 0.001$. When dyads with girls and dyads with boys were considered separately, non-Latinos ($M = 2.68$, $SD = 2.21$) received more encouragement than Latinos ($M = 1.56$, $SD = 1.95$), $p = 0.031$, whereas there was no difference between non-Latinas and Latinas. The proportion of encouragement did not vary as a function of child gender overall or parent gender.

3.1.3. Questioning by the Parent

Parental questions included the sub-categories of (1) questions to determine or deepen the child's understanding, (2) questions aimed at prompting the child to perform an action, and (3) other general questions, such as "What?". None of the types of parental questions varied as a function of ethnicity or gender.

3.1.4. Number of Parent Utterances

Although the parents were talkative, the number of parent utterances did not vary as a function of ethnicity or gender.

3.2. Child Behaviors

3.2.1. Exploration of the Activity

While completing each activity, some children explored and worked through multiple paths whereas others completed the activity in a single linear attempt. Exploration of the activity varied as a function of ethnicity. Latiné children (M = 0.13, SD = 0.20) engaged in a higher proportion of exploration than non-Latiné children (M = 0.08, SD = 0.12), $p = 0.049$. When the girls and boys were examined separately, Latinas (M = 0.15, SD = 0.22) explored the activity more than non-Latinas (M= 0.05, SD = 0.11), $p = 0.035$, whereas there was no difference between Latinos and non-Latinos. Exploration did not vary as a function of child gender overall or parent gender.

3.2.2. Amount of Time Spent Engaged in the Activities

The children consistently completed all six activities. However, the amount of time (number of minutes) they spent engaged in the activities varied as a function of ethnicity. Latiné children (M = 41.11, SD = 12.57) were engaged in the activities for more time than non-Latiné children (M = 35.11, SD = 10.08), $p = 0.002$. When girls and boys were examined separately, Latinos (M = 39.35, SD = 11.24) were engaged in the activities for more time than non-Latinos (M = 33.40, SD = 10.61), $p = 0.027$, whereas there was no difference between Latinas and non-Latinas. Amount of time spent engaged in the activity did not vary as a function of child gender overall or parent gender.

3.2.3. Number of Child Utterances

The children tended to be talkative, as indicated by the number of their utterances. The number of child utterances varied as a function of ethnicity. Non-Latiné children produced more utterances (M = 189.07, SD = 91.86) than Latiné children (M = 157.24, SD = 112.89), $p = 0.015$. When the girls and boys were examined separately, non-Latinas (M = 206.24, SD = 91.84) produced more utterances than Latinas (M = 150.57, SD = 94.83), $p = 0.013$, whereas there was no difference between the non-Latinos and Latinos. The number of child utterances did not vary as a function of child gender overall or parent gender.

3.2.4. Questioning by the Child

Child questions were coded as binary (i.e., the child's conversational turn either included a question or it did not), rather than based on type, because it was often difficult to determine the intent of the children's questions. While the children asked many questions, their overall number of questions did not vary as a function of ethnicity or gender.

4. Discussion

Parental support of their children's science learning is critical for all students. It increases children's self-concept, interests, attitudes, self-efficacy, participation, and career aspirations in science-related fields [5,7,8,43]. Parental support can be provided in a myriad of ways. For families from culturally and linguistically diverse backgrounds, that support can look and sound different than what is often expected in and from schools [4,13]. Furthermore, while some parents may not feel as confident with science content (i.e., due to a lack of science interest or science background), science support can take many forms that do not require formal science expertise [7,37,38,46]. Rawlinson et al. [79] (p. 286) point out "the importance of family in nurturing engagement in science and developing science-specific *capital* collectively as a family". Our research study investigated the behaviors of upper elementary school-age children (namely, exploration of and engagement in an activity, use of questions, and talkativeness) and their parents (namely, helping, encouragement, use of questions, and talkativeness) as they completed hands-on science activities together. Such experiences develop their science-specific capital while drawing from their familial and linguistic forms of community cultural capital [4]. The families in this study were generally interested and engaged in the hands-on science activities, as indicated by the significant time spent on the activities, their exploration of the activities, and discussion of the activities.

Regarding parental behaviors, in our study, all parents provided similar amounts of verbal support as evidenced by their amount of talk (i.e., number of utterances), which did not vary as a function of ethnicity or gender. Parents in the study were able to focus on helping their children as they participated in the activities. This tells us that schools and out-of-school programs that foster similar environments may assist children and families in their science-related studies just by providing them with a time and space to learn together, as suggested by O'Sullivan, Chen, and Fish [38].

Many of our Latiné families were bilingual such that the parents spoke predominantly in Spanish while their children spoke predominantly in English. Recruiting materials were disseminated in both Spanish and English, and bilingual session hosts returned calls to confirm family appointments, so that families felt comfortable participating in either language and honored their families' linguistic cultural wealth [4]. These families appreciated the opportunity to participate in bilingual activities. Similarly, if informal learning environments such as science centers, museums, and out-of-school outreach programs offer materials in both Spanish and English, families will be more likely to participate in informal, hands-on activities [80–82].

Parents helped their children throughout the activities. Interestingly, mothers provided more help through stating an observation about a problem as compared to fathers. Observational skills are very important for science inquiry [83], and the modeling of this behavior may benefit all children. The finding that mothers and fathers did not differ in their overall number of utterances, however, indicates that fathers may offer different helping behaviors that were not included in our study. For example, Tennenbaum and Leaper [73] noted that fathers in their study used more cognitively demanding language than did mothers in their interactions with their 6th and 8th grade children during a science task. Students may benefit from a variety of forms of help such that mothers and fathers alike can be helpful supporters of their children's science interests, identity, and participation.

Encouragement is beneficial for all students and their development of interests and attitudes about and self-concept in science-related subjects [5,36,39,40,45]. Unfortunately, parents are often not in the habit of offering a lot of encouragement, as we observed in this study. Although parents overall offered few encouraging statements, non-Latiné parents offered more encouragement than Latiné parents, and, specifically, parents of non-Latiné boys offered more encouragement than parents of Latinos. Encouragement helps children develop positive feelings, interest, self-competence, and exploration with science [5,36,40]. Programs that work with families may want to emphasize the importance of parental encouragement to help their children persist and engage with STEM fields given the critical role that encouragement plays [49]. In addition to explicit verbal encouragement, implicit nonverbal cues by the parent (such as enthusiasm for and involvement in science activities) may model positive attitudes toward science for their children [7,37,38].

Parents, regardless of ethnicity and gender, engaged by asking their children questions. By doing this, parents can help their children simply by engaging with content regardless of their prior level of content knowledge [70,74]. In a qualitative study of parent–child interactions during science activities, parents of 4th graders primarily used questions to prompt their children to act or respond and, moreover, their questions had the desired effect [77].

Regarding the children's behaviors, the children in this study similarly engaged with asking questions, regardless of ethnicity and gender, consistent with the observations of Silander et al. [50]. Children of this age (4th grade) tend to still be curious about science topics as the first large decline in girls' interest in science and math takes place during the middle-school years as science gender stereotypes are socialized [9,30,31]. Informal science education programs would benefit from emphasizing the importance of guiding children's understanding by asking questions, similar to the strategy outlined by Vandermaas-Peeler et al. [70]), rather than just telling a child the answer or how to do a task [77].

The families completed all of the activities, working until they had completed each task. Latiné children, however, engaged in the activities for a longer amount of time than non-Latiné children, indicating interest in the task. Their time on task may also indicate science capital (i.e., science interest, identity, and self-efficacy). We noticed that some children rushed through the activities. In particular, the non-Latino boys engaged in the activities for less time than the Latino boys. Attempting to finish quickly is not beneficial as students may rush through or skip steps in the science learning process.

Although Latiné children in this study spent more time than non-Latiné children engaged in the activities, they were less talkative in terms of the number of utterances. This was especially true for the girls (i.e., we saw the greatest difference in the number of utterances for non-Latina girls compared to Latina girls). While the families were actively engaged with the props and they were equally focused on the activities, they did not talk through the activities in the same manner. This was consistent with the findings of Rogoff and her colleagues (e.g., [11,84]), who found that during Latiné adult–child interactions, a child may rely more on learning through observation, guided participation, and intent participation (which are mostly nonverbal) than on verbalizations compared to their non-Latiné peers. This reminds us of the need to be much more expansive in our current perceptions of what is valued as engagement with science [85].

In our study, Latiné children (Latinas in particular) explored multiple paths to completing the activities, more than did non-Latiné children. Students may need to be encouraged to take their time and explore as the goal in science activities is to work through the process in a thoughtful and meaningful way. We are applying what we learned in this study about that principle to a follow-up study that we currently have in progress. For that study, we have developed and implemented 7-week science enrichment programs for parents to work with their 5th and 6th Latina daughters on hand-on science activities. One of the parent behaviors of interest in that study is slowing down their daughters as needed in an attempt to prevent them from rushing through the steps.

5. Conclusions

Children's participation in science, as well as the support they receive from their parents, may look different for children and/or parents from different cultures or genders. Each culture may learn strategies from the other that could benefit all students. Examples from our study include the findings that Latiné students spent more time overall on the activities and that they exhibited more exploratory problem-solving behaviors, even though they produced fewer utterances. These students may spend more time making observations, participating with props, and drawing figures of their systems (such as the locations of garden plantings or the construction of an electric circuit) and using other nonverbal problem-solving strategies. These active-learning, hands-on, experiential learning behaviors are beneficial for all students because they build foundational science inquiry skills [86–88]. Indeed, some of these behaviors have been observed in other studies with Latiné students [12,84].

Children benefit from parental support, and this study demonstrated the multiple ways in which parents support their children. Educational programs (formal and informal) can support parents in many ways by emphasizing that parents do not need to have significant content knowledge to support and encourage their children. Indeed, these programs may support families simply by setting aside time for parents and children to work together on educational activities. Further, the use of bilingual materials will provide a more inclusive environment that makes Latiné and non-Latiné families alike feel welcome.

Our findings regarding the time on task as compared to the amount of talk have implications for how we study parent–child behaviors across cultures and highlight the importance of examining nonverbal behaviors in addition to verbal ones in order to capture a complete picture of parent–child interactions. It is important to examine different forms of interactions, such as verbal and nonverbal, and quantities of interactions in order to capture both preferences as well as learning outcomes. Formal and informal educational environments would benefit from including opportunities for children (and their parents) to participate in both verbal and written tasks (such as writing a hypothesis) in addition to nonverbal (such as drawing diagrams) manners. Both skills are valuable science inquiry skills, and they will allow for the more inclusive participation of Latiné students, especially Latinas.

In addition, formal and informal educational environments may want to provide examples of verbal and nonverbal praise that parents can use with their children, such as saying “great job!” or “don’t give up!” when they complete part or all of the steps in an activity or giving their child a high five or fist bump. Nonverbal behaviors, which we did not analyze in this study, may account for some of the differences in encouragement that we observed between Latiné and non-Latiné families. It is also important to note that encouragement can be expressed in ways beyond praise and that attending to this aspect of socio-emotional support can be culturally mediated. While work by Bueno et al. [49] did not directly identify praise as a means of socio-emotional support provided by parents to Black, Latiné, and Indigenous students, they did document the vital ways in which parents support their community-college students pursuing STEM degrees. Examples of this support included listening, validating, affirming, and providing advice. In order to be as inclusive as possible, programs would benefit from being aware of the cultural norms for the various communities being served that may impact parental behaviors, including diverse ways of expressing encouragement.

Programs that work with families may also stress that exploration through trial and error (as was more commonly exhibited in our Latiné, and especially Latina, group) is an excellent problem-solving strategy that is employed during the engineering design process. Scientists and engineers generally have to refine their theories or designs over numerous iterations [89,90]. Through encouragement, parents can foster positive feelings that will help a child persist in their participation in science-related activities even if they are challenging.

These findings have important implications for how we understand how children from different cultures learn science. The non-Latiné families emphasized science inquiry skills common to Western education (e.g., verbal hypothesis testing) while the Latiné families focused more on observation, consistent with the findings of Silva et al. [12]. A cultural disconnect between practices of one’s culture and Western science education practices may favor some students’ interests and opportunities to succeed in STEM classes [12]. Therefore, it is critical that programs expand the ways in which they are culturally responsive in both the topics and interests addressed as well as the choice of pedagogical practices. The development of science inquiry skills and communication of science are critical to future success in science fields, as we learned from Lee and Luykx [91]. Furthermore, we did not include siblings in the study, and in some cases, they may have more influence on acculturating their younger siblings into these Western educational settings [47] and science education in particular [48].

The findings of this study are relevant to parents and educators of all children, regardless of ethnicity or gender, and they have implications for researchers in multiple fields, such as education, psychology, STEM, and bilingualism. For example, it would be interesting in future research to ask children to reflect on the encouragement (or lack thereof) that they receive while completing science activities with respect to how confident, engaged, or challenged they feel. In addition, the results may inform parents, educators, and researchers about how parental support behaviors differ among different ethnic populations and between boys and girls, and how parents may influence their children's attitudes, interests, and behaviors. Furthermore, educators may more fully engage underrepresented students by modeling and implementing more nonverbal strategies, such as drawing and observations, which are important science skills.

The implementation of these recommendations has the potential to increase the participation of Latiné and female students in science. The authors' next project involves working with parents of Latina girls to develop and implement family science programs (based on the finding of this study) to assist them in feeling confident in their ability to participate with their daughters in science activities. In addition, if educators and parents help girls and students from other underrepresented groups recognize that many of the skills that they have (e.g., asking questions, persisting while solving challenging problems) are assets that are relevant to participation in science (i.e., reflecting science capital), it may enhance their sense of self-efficacy and interest in STEM, and they may choose to pursue that interest. Furthermore, as Solis and Callanan [13] advocate, we must be sensitive to diversity in science learning and, moreover, be mindful of this while mentoring teachers-in-training in teacher education programs.

A potential limitation of this study was that the participants were self-selected, as is the case for many studies on family interactions during science activities. It is possible that these families were more interested in science than are families in general. To minimize this possibility, however, families were recruited from a variety of locations and the sessions were not conducted at science centers or similar locales. This may have encouraged participation from families with a wide variety of interests and experiences not limited to science. An additional advantage of not conducting the sessions at a museum or science center is that those venues may be expensive and may not have as much attendance from low-income families.

The present paper highlights the importance of studying behaviors of children and parents in informal science learning contexts. It also highlights the diversity of behaviors of both children as well as their parents as they provide support for their children's science learning. This may be particularly important due to the lack of time available for science in classrooms given the increased emphasis on language arts and mathematics in many elementary schools. Out-of-school family science opportunities for young children may model for them the importance of science in our lives and enhance their interest in science.

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Appendix A

Appendix A.1. Dependent Measures

Appendix A.1.1. Child Behaviors

Exploration of the activity: If the parent–child dyad worked through multiple strategies to complete the activity (rather than completing it from beginning to end in a single attempt), it was coded as exploration. For example, the child might try solving the problem using the props supplied but then move on to drawing out the problem on paper, or, for the electric circuit problem, they might connect wires such that the circuit does not light the first time, then reconfigure wires until it lights.

Questioning by the child: Child questions were coded as binary (i.e., the child's conversational turn either included a question or it did not). Some of the examples of the questions we observed included asking about the process to use to solve a problem (e.g., "What should we do first?"), their previous experience with the process (e.g., "Like at the museum with the magnet?"), the materials (e.g., "How do I use the heart rate monitor?"), what the parent's answer or hypothesis was (e.g., "What is your hypothesis?"), whether they had solved the problem correctly (e.g., "Was that right?"), and asking for the repetition of a word or phrase from the parent (e.g., "What?", "Huh?"). Unlike the parents' questions, children's questions were not coded by type because it was often difficult to determine the intent of the children's questions.

Amount of time spent engaged in the activities: This was the number of minutes each parent–child dyad spent working on an activity (from when they picked up the materials and started reading the instructions to when they finished writing their response and finished talking about the activity and put the materials away). This was calculated using the SALT computer program [76].

Number of child utterances: This was calculated using the SALT computer program [77]. Following the conventions of the SALT, utterances were similar to sentences and were distinguished by pauses, intonation, and grammatical rules. A child's utterance could consist of a single word or multiple words.

Appendix A.1.2. Parent Behaviors

Helping behaviors by the parent: Binary coding was used for each of three types of help for each activity—(1) Direction: telling the child what to do to solve the problem, without explanation of why, or directing scientific experimentation (e.g., "Connect these wires like this", "Let's make a prediction"); (2) Explanation or Answer: providing explanation, or stating an answer or prediction (e.g., "This one floats because it is so much lighter than the water", "I think it is going to sink); and (3) Observation: stating an observation relating to the solution of the problem or reflecting on the outcome of a prediction (e.g., "It tasted tangy around the tip" or "Alright we got one right").

Questioning by the parent: Each question asked by the parent was coded as one of three types: (1) Question about understanding: questions to determine or deepen the child's understanding, or asking for the child's explanation (e.g., "Why would you plant the cactus there?" or "Can you explain that to me?"); (2) Prompting question: questions aimed at prompting the child to perform an action, make a choice, or make a prediction (e.g., "How should we use the magnet to separate the mixture?", "Is it going to sink or is it going to float?"); and (3) Other general question: any general type of question not included in the categories above, such as asking for the repetition of a word or phrase from the child (e.g., "What?" or "Ready?").

Encouragement from the parent: Encouragement was coded as binary for each parental conversational turn. It included encouraging in a general form (e.g., "good job"), providing detailed or complex encouragement (e.g., "that's a good idea to try to add them up first"), and encouraging the child to continue with the activity (e.g., "Keep going, almost there" to continue exercising during the heart-rate activity).

Number of parent utterances: This was calculated using the SALT computer program [76]. Following the conventions of the SALT, utterances were similar to sentences and were distinguished by pauses, intonation, and grammatical rules. A parent's utterance could consist of a single word or multiple words.

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