"If I had to do it, then I would": Understanding early middle school students' perceptions of physics and physics-related careers by gender

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[This paper is part of the Focused Collection on Gender in Physics.] This study examined the perceptions of 6th grade middle school students regarding physics and physics-related careers. The overarching goal of this work was to understand similarities and differences between girls' and boys' perceptions surrounding physics and physics-related careers as part of a long-term effort to increase female interest and representation in this particular field of science. A theoretical framework based on the literature of girl-friendly and integrated STEM instructional strategies guided this work to understand how instructional strategies may influence and relate to students' perceptions. This convergent parallel mixed-methods study used a survey and focus group interviews to understand similarities and differences between girls' and boys' perceptions. Our findings indicate very few differences between girls and boys, but show that boys are more interested in the physics-related career of engineering. While girls are just as interested in science class as their male counterparts, they highly value the social aspect that often accompanies hands-on group activities. These findings shed light on how K-12 science reform efforts might help to increase the number of women pursuing careers related to physics.

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I. INTRODUCTION

According to the American Physical Society, women accounted for roughly 20% of bachelor's degrees in the fields of physics and engineering in 2010 [1]. This is lower than the 35% observed across all science, technology, engineering, and mathematics (STEM) fields and significantly lower than the nearly 60% of degrees awarded to women in biology [1]. These skewed distributions are likely related to young girls' K-12 education experiences, particularly their experiences *prior* to high school [2–8]. Evidence suggests that middle school is the time in which young women's perceptions of STEM are formed, which may affect future career aspirations [7,9–15]. There are no significant gender differences in academic achievement in middle school, yet young women have less positive attitudes towards careers in science than their male peers [5,6,9]. This suggests that the low representation of women in STEM fields is a result of not their abilities, but their perceptions; for fields like physics where negative perceptions persist [5,16–19], it is clear that middle school is a critical time to intervene. However, in order to improve perceptions, there is a need to understand what perceptions currently exist. Various factors, including social and cultural factors, affect perceptions, and looking at the role of K-12 education in the lives of young women and men may help to identify specific differences in perceptions of physics and physics-related careers.

This work aims to understand 6th grade students' perceptions of physics and physics-related careers. This choice in grade level is guided by the inclusion of basic physics concepts in the Minnesota state science standards [20] as well as those present in the *Next Generation Science Standards* [21]. It is additionally informed by the literature, which indicates middle school as a critical time when it comes to forming attitudes about STEM fields [7,9,10,14,15]. The research question guiding this study is, *What differences exist between 6th grade girls' and boys' perceptions of school physics and physics-related careers*?

II. LITERATURE REVIEW

A. Gender equity in physics

Gender equity in STEM education has been of concern to researchers who strive to understand the underrepresentation of women in the STEM fields. For many years, the prevailing theory held that women did not pursue science because they were not as talented at mathematics and science as their male counterparts [5,9,22–24]. A look at the performance of girls in K-12 science today, specifically in recent results of the National Assessment of Educational Progress and the Program for International Student Assessment (PISA), shows that the once-thought achievement gap between girls and boys in mathematics and science no longer exists [5,9,25,26]. Though the results of the PISA have additionally shown that general interest in science careers is similar for 15-year-old girls (27%) and boys (24%) across various countries [6], this is not the case in the United States, where by the end of high school only 12% of girls are interested in pursuing STEM careers, versus 40% of boys [3].

There has been a constant and consistent disparity between the two sexes when looking specifically at those who pursue physics and engineering, two fields that continually fail to attract women [1,5,16–19,24]. This may be highly influenced by social and environmental factors, including K-12 educational experiences [27,28]. Over 50 countries report that women are more likely to choose life sciences over physical sciences [5,6,29]. Even at the elementary level, girls are drawn towards the social and natural sciences for science fair project topics compared to boys, who are drawn towards physical science [22]. This suggests that social factors play a role in what attracts girls and boys to specific sciences, as these choices fall under the assumption that physical science is masculine [5,22,30]. As a whole, students' interest in physical science begins to decline as early as upper elementary [12,31,32].

The perception of physics as a masculine field dates back to World War II, where physics, "conjured up images of factories and machines, harsh rationality, and cold, inanimate nature" (Ref. [24], p. 121). This cultured gendering of physics itself may be one of the reasons why few outside of the male-normative society go into physics. Further, studies have shown that girls and women have a skewed vision of physics, seeing it as a career that involves working alone [33,34].

B. Focus on middle school

Several researchers have identified the middle school years as vitally important when it comes to developing attitudes about STEM fields [3,9,14]. First, the greatest changes in students' attitudes towards science occur at each transitional stage in education, one of which is the shift from elementary to middle school [8]. Archer *et al.* confirm this by stating, "Research has demonstrated that the majority of young children have positive attitudes to science at age 10 but that this interest then declines sharply and by age 14, their attitude and interest in the study of science has been largely formed" (Ref. [10], p. 617). Further, the National Research Council has an interest in encouraging a diverse population (including women) to pursue science careers and has acknowledged that "girls' interest in science dramatically declines compared to boys' as students transition into middle school" (Ref. [7], p. 281). In fact, the middle school years may be *the* formative years for which young women's opinions of STEM are formed, as initiating students' interest in STEM careers during high school is incredibly difficult to do [3,35]; this may influence their future career paths.

Student decisions to pursue a STEM career are conceived sometime during high school, and quite possibly by 8th grade [2–4]. By 8th grade, many career aspirations are established; thus, early exposure to physical science and engineering is critical [4]. High school freshmen's interests in STEM careers are a known predictor for determining career interest when students reach higher education, but if these interests are low at the end of middle school, there is little chance of increasing the numbers [3]. For instance, Sadler *et al.* found that boys maintained around a 40% interest in STEM fields throughout high school in the United States, where girls' interests significantly dropped from 15.7% to 12.7% [3].

By the time students reach high school, low attitudes towards STEM careers exist for young women and decline even further over time [3]. If the trend is for the further loss of interest of girls in high school, then educators and educational researchers need to find a way to increase interest in STEM *before* that time, sometime in the middle grades, when girls have shown an interest in science, but have identified it as a "not for me" career [11,35]. This reflects an identity conflict that students experience such that 10-year-old students differentiate between "doing science" and "being a scientist" and this differentiation is important to understand the mismatch between students' science identities and their personal identities [10,30]. While students enjoy the act of performing science, they often fail to see alignment between their personal identity and the science identity that they have created for themselves; this identity is assumed to have been shaped by sociocultural influences, including stereotypes [10,11,33].

Though students at the age of 10 have a limited understanding of what a future science career involves, they strongly associate it with masculinity [10]. Additionally, the Draw a Scientist Test used by Scherz and Oren found that "the common image was that of a scientist as a bespectacled male with unkempt hair in a white lab-coat" (Ref. [36], p. 977). Since career aspirations are guided by seeing how a career identity fits [37], if a scientist's identity is not desirable, students will not choose to pursue science as a career [10]. This is especially problematic for those who do not fit the stereotype that children associate with being a scientist. This stereotypical image is one that marginalizes students who do not physically look the same. For girls in particular, at the very least they must find ways to balance the identities of femininity and science, and fields like physics are strongly associated with masculinity [10,11,30]. Understanding students' perceptions may lead to identifying how to increase female participation in science fields, such as physics, where there is a large underrepresentation by females.

C. Theoretical framework

The National Research Council has concerns about the decline in K-12 students' interest in STEM careers [7]. This fear is not unfounded, especially considering the underrepresentation of certain groups, which includes women. Researchers suggest the importance of the role of the teacher and voice the need to examine current teaching strategies and how those strategies may influence students' perceptions, identities, and career aspirations [30,33]. Specifically, they point to the positive influences that "gender-inclusive" education can have on girls' interest and achievement in science disciplines [30]. This is especially important when considering current work in K-12 science education that puts pressure on science teachers to integrate STEM in their classrooms. If teachers are responsible for multiple STEM disciplines, the educational community must do its best to be inclusive of all students. Considering that engineering is another discipline that suffers from a small female presence in the work force [1], there is a need to assure that its inclusion in K-12 education does not have the same results as physics currently does. As engineering is relatively new to K-12 education, there is much to be learned about its inclusion at this level of education.

Given this issue, various researchers have spent time exploring what the literature refers to as girl-friendly science instruction [16–19,31,38–40]. The original purpose of this line of instruction was to address the low science self-concept that girls have maintained. Science self-concept refers to one's belief in his or her science abilities, and for physics this has been consistently low for girls [5,16–19]. The higher the self-concept a student has in a given field of study, the more likely that student is to further pursue that field [26]; thus, when researchers report that girls have lower science self-concept than boys [6], we can begin to understand how women might be less likely to pursue a career in the sciences. It may be the case that girls are more critical of their abilities and thus are more likely to think they are not talented, preventing them from choosing a career that they are equipped to pursue successfully. Because physics is so highly underrepresented by women and negative self-concept related to this field persists, the development of girl-friendly science has typically been around physics [16,17,19]. Though the name indicates this instruction is for girls, it has been shown to be beneficial to boys [16,17,19].

Girl-friendly instructional strategies have the effect of positively influencing young girls' perceptions of science, including their science self-concept [16–19]. These strategies include making content relatable to everyday applications through the use of societal connections and connections to prior experiences [16–19,31,38–40]. Making these connections to real-world applications in a physics class positively and significantly impacts not only girls' but boys' expectations for success in future physics courses [16–19]. Interactive discussions and experiences in physics classes also have positive impacts on both boys' and girls' beliefs regarding their science achievement [19]. In particular, both girls and boys "are interested in physics in the context of its practical applications, its potential to explain natural phenomena, or in the context of chances and risks which lie in physics-based technologies" (Ref. [17], p. 704). While various guidelines and suggestions are available, it is evident that the teacher plays a large role in creating an environment to foster the development and growth of students' positive science self-concepts.

Recent national documents suggest STEM instruction as a way in which science and engineering can come to life for girls in K-12 education [7]. The *Next Generation Science Standards* [21] focus on this with a strong emphasis on scientific and engineering practices rather than a simple memorization of scientific facts, promoting STEM in an integrated manner [7,21]. Oftentimes engineering is used as the "glue" or "bridge" between one or more of the disciplines through the use of an engineering design challenge [26]. Integrating engineering into science may be a way to gain and maintain self-concept and interest in young girls since it has the ability to actively engage students in a realistic problem or challenge where students apply their science content knowledge, something that has been found to be important in girl-friendly science instruction [17]. The integrated STEM framework discussed by Moore *et al.* shows promise for this, and aligns to many of the guidelines found in the girl-friendly science literature (see Table I) [41]. These STEM integration approaches allow students to work with their hands, talk about science in groups, and relate science to human problems, much like the suggestions of girl-friendly instructional strategies promote; thus, these aspects fit many of the recommendations for an effective girl-friendly curriculum.

The theoretical framework adopted for this study combines several tenets present in girl-friendly instructional strategies [16,42] with the integrated STEM framework of Moore *et al.* [41]. There is a clear alignment between the

TABLE I. Comparison between girl-friendly and integrated STEM strategies.

Girl-friendly strategies [16,42]	Integrated STEM framework [41]
1. Provide opportunities to be amazed.	1. Motivating and engaging context.
2. Link content to prior experiences.	2. Inclusion of mathematics and/or science content.
3. Provide first-hand experiences.	3. Student-centered pedagogies.
4. Encourage discussion and reflections of the social importance of science.	4. Engineering design challenge or redesign.
5. Physics appears in application-oriented contexts.	5. Learning from failure.
6. Relate physics to the human body.	6. Emphasis on teamwork and communication.
7. Experience physics quantitatively.	
8. Engage in collaborative learning.	

goals of girl-friendly instructional strategies and STEM integration. In both cases, the goal is to not only increase the level of student achievement, but also to increase students' interest in STEM careers. Table I shows how not only the overall goals of the frameworks are aligned, but spells out the independent tenets of these frameworks. A comparison between several girl-friendly instructional strategies [16,42] and the integrated STEM framework of Moore *et al.* is shown to emphasize the importance of the work presented here [41]. Alignment between these two frameworks is vital in understanding how a combined instructional framework may be beneficial to increase girls' science self-concept and STEM career aspirations. By comparing the lists of tenets in each of these frameworks, one can find similarities. For instance, one might imagine that the motivating and engaging context discussed by Moore *et al.* [41] is similar to tenets 1, 2, 3, and 5 of the girl-friendly instructional strategies [16,42]. Similarly, an engineering design challenge or redesign may allow students to see how physics appears in application-oriented contexts. There is no one correct answer for how these frameworks overlap, but, in general, it is easy to see the similarities; specific overlaps of individual tenets would depend on a specific curriculum in question. It is possible that by combining physics with engineering in a way such that girl-friendly strategies are used, positive perceptions of physics can be formed and maintained with the appropriate instructional strategies.

III. METHODOLOGY

A. Research design

This work was part of a larger mixed-methods study in which middle school students' perceptions of physics and physics-related careers were examined over the first half of two 6th grade classrooms' school year following a summer professional development in 2014, during which their teachers (along with 40 other elementary and middle school science teachers) participated. The main focus of this professional development was to engage teachers in developing integrated STEM curricula, using the integrated STEM framework of Moore *et al.* [41]. Teachers who chose to focus on physical science were also exposed to girl-friendly instructional strategies [16,42] during the professional development. In the state of Minnesota, the 6th grade science standards focus on basic physics concepts, such as motion, forces, light, energy transfer, and the particulate nature of matter. Additionally, 6th grade is the first time that students attend a science class on a daily basis. The work presented here follows a convergent parallel mixed-methods design as described by Creswell and Plano Clark [43]. In this design, quantitative and qualitative data are collected and analyzed separately, yet simultaneously, before comparing the findings of each in order to address the research question [43].

The larger quantitative data set consisted of physics perceptions surveys from 165 6th grade students. The purpose of this survey was to gain an understanding of both girls' and boys' perceptions of physics and physics-related careers at the time they began middle school. Additionally, the survey asked students about their instructional preferences in science class. Qualitative semistructured focus group interviews followed administration of the survey in order to dig deeper into understanding students' perceptions as well as what factors might influence them, specifically focused on instructional strategies. This second set of data employed the use of an explanatory case-study design with two cases: girls and boys [44].

B. Data collection

Data collection occurred within the first month of the 2014–2015 academic year at a suburban middle school outside of a major Midwest city. The classrooms were selected based on the first author's familiarity with the two 6th grade teachers at this school, which grew out of the aforementioned 2014 summer professional development. All students in these classes were asked to complete a 15-item Likert-scale survey with a 0–4 scale representing *Strongly Disagree* to *Strongly Agree*; Cronbach's alpha of the survey showed good internal consistency with $\alpha = .73$. This survey was designed to address students' perceptions of physics in school, physics as a career, and instructional preferences, using the theoretical framework as a grounding. As early middle school students may not be familiar with what concepts physics includes, a brief description was included at the top of the survey based on the advice from the teachers of these two science classes. The wording of the survey was also checked with the science teachers to assure use of kid-friendly language. Students were asked to identify which gender they most associated with by circling *female* or *male* at the top of the page; this resulted in students identifying their gender based on their sex. A total of 76 girls and 88 boys completed the survey.

Focus groups were created based on returned parent consent forms and whether the student had completed all items on the survey. A total of 27 students participated in four separate focus group interviews during their lunch; the breakdown of the groups is shown in Table II. These focus groups were separated by gender and science teacher. Each of the four interviews lasted roughly 20 minutes and allowed

TABLE II. Data collection details.

	Teacher 1 (male)	Teacher 2 (female)
Completed surveys	$N = 89$	$N = 75$
Girls	41	35
Boys	48	40
Focus group interviews	$N = 11$	$N = 16$
Girls	6	9
Boys	5	7

TABLE III. Demographics of students who participated in focus group interviews.

	Teacher 1 (male)	Teacher 2 (female)
Girls		
Caucasian	Samantha, Lindsey	Zara, Ashlyn, Cass, Jessica, Evelyn, Lisa
African American	Alisa, Monet	Roberta, Raylen, Brianna
Asian American	Rachel, Megan	
Boys		
Caucasian	George, Thomas, Robbie	John, Joe, Nate, Frank, Lloyd
African American		Donovan, Jimmy
Asian American		Felix
Latino American	Jose, Preston	

students to elaborate on their physics-related perceptions in a small social environment surrounded by single-sex students with whom they were familiar. The same person, the female first author, interviewed all groups. Classroom observations were also conducted and used as a secondary source to provide context and understanding for the interviewer.

Students who participated in focus groups represented a diverse population. The school district student population is 73% Caucasian, 11% Asian American, 9% African American, 7% Latino American, and 1% American Indian. The two female groups (case 1) were composed of 8 Caucasian, 5 African American, and 2 Asian American girls in total. The two male groups (case 2) were composed of 8 Caucasian, 2 African American, 1 Asian American, and 1 Hispanic American boys in total. Table III shows the demographic breakdown of the two cases by teacher.

IV. ANALYSIS

Because of the nature of the convergent parallel mixed methods, both the survey and interview data were analyzed nearly simultaneously. Paper surveys were administered, collected, and organized in a spreadsheet, but not analyzed before focus groups took place. Analysis of the surveys intentionally occurred after the interviews so as to not bias the coding of the interviews. As statistical tests had been determined ahead of time, there was minimal risk for the analysis of the interviews to interact with the analysis of the surveys.

Each item on the survey was analyzed using a two-group Mann-Whitney-Wilcoxon rank-sum test to examine differences in physics-related perceptions between 6th grade girls and boys. The level of significance in these items was limited to $p < 0.1$, a cutoff commonly used in educational research. Cohen's d was calculated in order to measure effect size of statistically significant items. Pearson's r correlations were also examined between survey items with a cutoff of $r > 0.4$ to limit the results to strong to very strong correlations.

Transcripts of the focus group interviews were coded using three predefined themes. The themes were created based on the interview questions that were asked to all four of these groups and pertain to the research question guiding this study: (1) what are students' understanding of physics, (2) what are students' perceptions of science in school, and (3) what are students' perceptions of science or physics as a career. A constant comparative method was employed for each case to generate an understanding of the within-case groups [45,46]. A cross-case comparison was used to synthesize the findings between the separate cases to better understand similarities and differences between them [45]. The gender-separated focus groups provide some indication of the level of different needs of middle school girls and boys in physics classrooms.

V. FINDINGS

A. Surveys

The Mann-Whitney-Wilcoxon rank-sum test revealed two items that differed significantly between girls' and boys' responses (Table IV). All other items were not found to be statistically significant, indicating little difference between girls' and boys' perceptions of physics and physics-related careers upon entering middle school. These results also indicate that girls and boys have similar preferences when it comes to their science learning. The two significant items reveal that boys are more eager to learn about how things work (item 1) and have a higher interest in their science class compared to girls (item 5). The small effect size indicates real-world significance [47].

TABLE IV. Statistically significant results of the two-group Mann-Whitney-Wilcoxon test.

Item	M_{girls}	M_{boys}	U	p	d
1. I like learning about how things work.	2.72	2.98	2709	0.035*	0.305
5. Science is one of my favorite classes in school this year.	2.27	2.55	2721	0.074~	0.269

$\sim p < 0.1$, $*p < 0.05$, $**p < 0.01$, and $***p < 0.001$.

TABLE V. Unique survey correlations using Pearson's r.

Correlated items of interest	Pearson's r
Girls only	
7. Learning physics can be helpful in my everyday life.	
14. I like participating in class discussions about science.	0.414***
Boys only	
1. I like learning about how things work.	
2. I am interested in the topics we will be learning in science this year.	0.449***
3. I like to learn about physics outside of school.	0.477***
5. Science is one of my favorite classes in school this year.	0.412***
8. Anyone can be good at physics.	0.455***
15. I like when I can relate to the topics we learn in science class.	0.424***
2. I am interested in the topics we will be learning in science this year. (e.g., particles, light, sound, motion, forces, energy).	
4. I would like to have a career where physics plays a role.	0.445***
5. Science is one of my favorite classes in school this year.	0.517***
6. I easily understand physics topics.	0.405***
7. Learning physics can be helpful in my everyday life.	0.534***
14. I like participating in class discussions about science.	0.427***
15. I like when I can relate to the topics we learn in science class.	0.424***
3. I like to learn about physics topics outside of school.	
7. Learning physics can be helpful in my everyday life.	0.500***
14. I like participating in class discussions about science.	0.532***
4. I would like to have a career where physics plays a role.	
15. I like when I can relate to the topics we learn in science class.	0.418***

$\sim p < 0.1$, $*p < 0.05$, $**p < 0.01$, and $***p < 0.001$.

Correlational analysis via Pearson's r revealed a larger number of strong to very strong correlations for boys (23) than for girls (10). Table V presents the unique correlations for girls and boys to show where there are differences. The only unique correlation for female students represents a connection between girls seeing the use in learning physics for their everyday life and participating in class discussions about science. This hints that discussions about real-world applications of physics may be a way to engage and interest girls.

What is most striking is that five survey items were correlated to one of the statistically significant items from the Mann-Whitney-Wilcoxon test (item 1). Because these correlations were not found in the girls' surveys, this indicates the extreme importance of boys' interest in learning how things work, something that physicists and engineers share in their career. Item 2 on the survey (*I am interested in the topics we will be learning in science this year*) was correlated with six other items, indicating an interest in learning physics topics with boys. While this item was not found to be statistically different between girls and boys, the number of correlations indicates that physics is something relevant and of interest to boys.

B. Focus group interviews

The focus group interviews centered around three main topics broken down by gender: (1) familiarity with physics, (2) science or physics in school, and (3) science or physics as a career. These students were generally unfamiliar with physics as a separate science discipline and career; thus, conversations tended to focus more on science as a whole.

1. Girls

(a) Familiarity with physics. When girls were asked to identify what they thought of when they heard the word physics, eight students identified physics as experiments or hands-on activities. One put forth the idea that physics made her "…think of scientists, like, the crazy scientists with the big goggles and the hair. And an explosion," much to the likeness of photos of Albert Einstein to which these girls had previously been exposed. Two students talked about physics in relation to the concept of forces and how the world works. One thought of numbers and two related it to the word *physical*.

The group from teacher 1's class talked at length about their experiences related to astronomy, with both an interactive astronomy experience they had the previous year and a "toy constellation" projector that was well known to the group. This theme of space and astronomy was exciting to the girls, but they did not see the connection to this field of science and physics. Two girls had even decorated their room with a space theme, though one of them had since replaced it, stating, "But you know when you have a favorite color, you just kind of get tired of it after a while. It's kind of like that, but I'm still interested in it. Just not as much as I was."

(b) Science or physics in school. In general, the girls were positive about science in school, using words such as "fun and exciting" to describe their experiences. Girls identified hands-on activities and experiments in science as one of the primary reasons why they enjoyed science in school. Additionally, they identified taking notes and listening to lecture as something they were not keen on. For example,

Evelyn: Um. So I really, I like science. I always like it more when we do interactive things, like where we get to do experiments and, like, mix things and test things.

Rachel: So, cause, um, it's really fun if you participate. You…it sticks in your brain if you actually do it. Like, like last year we read from a textbook and took notes. It wasn't really that much fun.

Ashlyn: Some stuff that I don't like…when we just have to sit there cause when I think about science, I always think of fun experiments, like, learning a bunch of stuff about how to do experiments and stuff like that.

These girls also identified that they enjoyed the social aspect of learning during hands-on activities. Monet mentioned, "And what was nice about that [activity] was that everyone actually took part in it and no one was left out and no one was doing all of the work." Active participation by all members of a group was something that these girls felt was important to their learning. They were frustrated by students who copied off of their notes or otherwise did not participate. Samantha stated, "I'm doing all of the work and they're just, like, sitting there." Similarly, Megan expressed frustration when students took advantage of her knowledge: "People just come up to us and think that we're brainiacs or something." These girls showed a preference for groups to be balanced such that all participated rather than (1) one student doing all of the work and (2) one or more students not participating.

Several girls identified a "strength in numbers" aspect to learning in science, seeing group work as an opportunity to work with new people and hear different opinions. Further, they saw the value of sharing knowledge in a group, as Brianna stated, "I think it's, like, easier to learn because, like, if you don't know an answer to a question or something, you have someone to help you." Lisa agreed with this, saying, "You get a second opinion and if you do something wrong, that's how you know if you have, like, a question and you're not sure, they can help you." This collaborative nature of working within a group was something that was seen as extremely beneficial to their learning.

(c) Science or physics as a career. Though these girls were interested in science in school, they were reluctant to say that they were interested in a career involving science. Alisa stated about pursuing a career involving science, "Like, if I had to do it, then I would. I wouldn't like hate it and dread it. But I think it's cool." Several of the girls saw science careers as something that might be fun and interesting, but as Cass pointed out, "I obviously wouldn't do it as a job." As a whole, two different types of responses presented in this conversation were (1) somewhat interested and (2) "I would rather." It is apparent that mixed attitudes regarding careers related to science existed for the girls, possibly because they did not know that science-related careers were not limited to being a scientist. Only one student, Monet, clearly indicated she was interested in a career involving science. Another student, Raylen, was interested in a career involving mathematics.

When asked to consider a job or career that specifically included physics, these girls reiterated their "stand-offish" approach to science careers, again stating that it might be cool, but they were interested in other careers. Rachel stated, "I wouldn't go for physics…I would do scientist…I would go for something, like, a kind of science area that I like." Further questioning led to marine biology being a large favorite amongst this group of girls. These girls also offered that they had other careers in mind. For instance, Cass stated, "Ok, um, I think it would be a good career choice for me, but I've already decided what I want to be." Jessica also mentioned liking the idea of a career related to science, but had something else in mind and said, "I think I would want to be something else." All of the other responses reflected this idea as well, with these girls having specific jobs in mind, such as a doctor, a teacher, a lacrosse player, and a home interior designer.

2. Boys

(a) Familiarity with physics. Dissimilar to the girls, the boys associated physics with specific science concepts, such as gravity, motion, lights, engineering, forces, electricity, and atoms. One student also thought of gym class, relating the actual word of physics to physical activity or physical education. The boys' familiarity with specific physics concepts may be the result of more exposure to these topics, perhaps in alignment to stereotypical norms that children often see [11,22].

(b) Science or physics in school. The boys were not as eager and excited about science as a class, but found that experiments made the class tolerable. Frank summarized the overall opinion when he stated, "It's ok—experiments make it a lot better." Specifically, they were interested in the "wow" factor of science, and as Nate stated, "Um, I like experiments where, like, there might be blowing stuff up." They also shared a specific interest in electricity. Thomas stated, "Well, in 4th grade, I liked doing things with, like, circuits and stuff." They also valued the hands-on aspect of science, as Frank stated, "It's not like you're listening to someone say, 'Do this, do this, do this.' 'These are the guidelines, do what you want with it.'" Jimmy agreed with this, stating, "Sometimes you can't really learn unless you, like, try it for yourself." He was also particularly interested in, "Building miniature models of things." Akin to the girls, these boys did not like taking notes or listening to, "long, boring lectures. On stuff you already know." As Jose simply

put it, “Anything that doesn’t include, like, doesn’t include… experiments,” was not interesting in science class.

In addition to an interest in first-hand experiences, the boys noted the freedom often associated with experiments. For instance, George commented, “I like, uh, when we get to come up with our own experiments, not necessarily like he [teacher 1] gives them—those experiments.” At the time this interview, teacher 1 had assigned students to design an experiment of their own to develop their knowledge and understanding of scientific inquiry. The boys from this class discussed this excitedly, sharing their ideas to create a system that would do things like charge a phone or power an MP3 player. For instance, George shared, “We’re going to see if a watermelon can charge your phone when it’s in a bowl of ice cold water.” He elaborated on how this experiment was going to be done, to which Robbie responded, “That sounds really cool.” Thomas then shared his idea of a similar experiment to use Gatorade and an onion to power an MP3 player. They were able to relate this to a previous conversation about renewable energy sources, stating, “Now we know what to do if, uh, the power runs out” (George). This fascination with electricity and circuits reflects Thomas’s earlier intrigue with this topic and demonstrates an interest in designing solutions to a problem.

The boys somewhat valued working in groups, but only when all participants were cooperative. Preston stated, “Like, when we work in groups on an experiment, like, that you get to, like, help with stuff, so that way you don’t, like, just do everything and then, yeah….” Groups were seen as a way to deal with a heavy load of tasks to complete. Only Frank mentioned the cooperative learning that took place in groups, stating, “Like, if you’re wrong and you’re by yourself, then there’s no one to say, ‘No, I think it’s this.’” He further elaborated by stating, “I like group projects because even if you are doing all of the work and you get a bad grade, it’s not all your fault.” Frank was clearly aware that there was an accountability that took place within a group. Several boys (Joe, John, and Donovan) seemed to prefer working by themselves, and as Joe put it, “I’m an independent worker.”

(c) Science or physics as a career. When asked about pursuing a career in science in general, boys’ responses reflected how they felt about science in school. Four of the boys were already considering engineering as a field of interest. This was not necessarily seen as a career involving science or physics, with George summing up saying, “And I wouldn’t want to go into a science field. I’m just not a fan—I like science, but not, like, as a career. If I were to go into a science field, I would definitely be an engineer.” Unlike the girls, the boys were less inclined to say that a career involving science would be worth considering, but if it was, it would be engineering. Some had decided that a science-related career was not worth considering at all, as Lloyd blatantly stated, “I’m probably not going to do anything that involves science.”

When asked about physics-related careers in general, these boys were able to note careers that related to physics, but also chemistry. One idea that was shared was the idea of being an “inventor” as representative of what a physicist is. When asked to discuss this to greater detail, Jose and George both discussed their need to create inventions that help people.

Jose: I don’t know…like, inventions that work to, like, help people and stuff like that.

George: If I were an inventor, I would want to invent stuff that would help us stop using fossil fuels.

Though going into a science career was something that the boys were not necessarily excited about, they were clearly interested in related fields, such as engineering.

VI. CONCLUSION AND IMPLICATIONS

A. Discussion

Survey results found only two of 15 items that were significantly different between girls and boys. These results indicate that, by the time students reach middle school, boys are interested in learning how things work and are interested in learning physics topics. This is also represented in the focus group interviews, wherein the boys indicate an interest in engineering, a field that would allow them to understand how things work given a knowledge of physics. None of the girls indicated an interest in engineering, but rather focused on enjoying science as a way to communicate with other students or engage in hands-on experiences. Girls were more focused on the role of participation in group work and how they benefit from working together, which they did not indicate was a part of a science career. This provides some insight as to what features of science may indicate to students, specifically females, that physics (and science as a whole) is not a cold and isolated field [24,24,33]. The girls, who did not show an awareness of specific physics concepts, focused on the fact that physics was a science that was filled with hands-on activities and experiments. It is clear that these girls had limited familiarity with physics as a science, something that may be a result of little to no exposure to “gendered” toys at a young age or simply in alignment to gendered stereotypes [22,30].

The nature of how students discussed physics-related careers is noteworthy due to the openness that the girls had to careers in science and physics. They had positive attitudes about science, but had other ideas about their futures. While students were happy with “doing science” in their school, many could not align with “being a scientist,” possibly because of their limited understanding of what scientists do; this is in concordance with previous research [10,11,35]. Specifically, they were interested in careers that directly help people with their problems (e.g., doctor, teacher, home interior designer). The boys, on the other hand, were divided since they either were not interested in a career involving science or were interested in careers that would allow them to invent or build, which are hallmarks of engineering. In both cases, however, students were limited in their understanding of physics-related careers. This is not surprising, since 6th grade is one of the first times that students are formally introduced to the discipline. This suggests that the development of science self-concept may in fact be crippled before students enter middle school due to this lack of early exposure to science in schools, thus stifling potential for early interest in science careers.

When considering the combined girl-friendly and integrated STEM theoretical framework, one can begin to see how these students' responses might be influenced by instructional strategies. First, all students were positive about the hands-on aspect of science. This is unsurprising as these types of activities have been a well-established piece of reform-based classrooms [48–50]. Further, these first-hand experiences ignite the positive responses to "doing science" as noted by other researchers, which contributes to students' positive perceptions of science at a young age [10,11,35]. The boys talked about the use of hands-on experiences that related to engineering and inventing. Though the girls never mention engineering, they talk about the teamwork skills and collaboration that is found in the framework used in this study.

The second piece of importance is the focus on group work, another tenet in the framework. While students were positive about group work, there was one important difference. Girls were more focused on the *collaborative* nature of group work. Boys saw group work as valuable, but not completely necessary. In thinking about the framework and students' career interests, it is possible that direct exposure to engineering would help these students "find their place" and help them see the overlap in their identity and the identity of one in a science-related career. By introducing students to science and other STEM careers early on in their education, it is possible to create a more sophisticated awareness of these fields that is currently lacking. This is reflected in the low science self-concepts reported time and time again [5,16–19]. By encouraging students to not only practice "doing science" in school, but by giving them the opportunities to practice "being a scientist or engineer," it is entirely possible to shift science self-concept from low to high. In turn, this may increase the number of students, specifically girls, interested in STEM careers, as this approach would likely minimize the propagation of the stereotypic image of scientists that still prevails.

B. Implications

Considering the current trends in K-12 education to increase STEM literacy for a diverse population of students [7,21], this work sheds light on what aspects of STEM and physics education may aid in improving and maintaining positive attitudes. The *Next Generation Science Standards* [21] promotes the engagement of students in science and engineering practices to not only include hands-on activities to learn content, but to develop the tools to develop in scientific and engineering thinking. Promisingly, Makarova and Herzog showed that science teachers perceived physics as being positive for both male- and female-associated words [30]. Knowing that teachers are perhaps the most important factor that influences students' attitudes towards science [51], it is possible that this "nongendering" of their own scientist stereotype could benefit students. Further, as will be explored below, by engaging teachers in girl-friendly practices, it is possible that the pivotal role of the teacher may positively influence students (particularly girls) in terms of their perceptions of science and science careers. This piece was examined in more depth as part of the larger study presented here [52].

The inclusion of engineering is something that will entice boys to participate in science class by allowing them to build and learn how things work. For girls, it seems that the social aspect maintained by group work during hands-on activities can show them what STEM fields are like in the real world. Perhaps the most promising feature that appears in the integrated STEM framework of Moore *et al.* [41] is the prominence of the real-world applications of science and mathematics content, which directly aligns with the findings of Häussler and Hoffman [17], in which they found that girls and boys are particularly interested in practical applications of physics. Additionally, the inclusion of these proposed practices would allow students to make connections to society as a whole, an avenue that was explored as part of the larger project presented here. This may be the key to increase female participation in physics careers. Perhaps by exposing students to a more accurate representation of science in their science activities as well as what scientists do for their job, fewer students will view physics as a field composed of "the crazy scientists with the big goggles and the hair. And an explosion."

C. Limitations

The biggest limitation of this study is that focus groups were conducted with students on a volunteer basis, which could limit the volunteer group to only students who were high achieving in science or who were inherently interested in science in some way, shape, or form. While the students who participated in focus group interviews came from diverse populations, the views represent only those from one suburban school. The results may not apply to rural or urban school districts. Another limitation to this study is that the interviewer was female, which may have had an effect on how students responded both in interviews and on the surveys. A future exploration that examines the effect of the sex of the interviewer on students' responses would help to address this potential issue.

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