Infusing Empathy Into Engineering Design: Supporting Under-represented Student Interest and Sense of Belongingness

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WIP: Infusing Empathy into Engineering Design: Supporting Under-Represented Student Interest and Sense of Belongingness

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Introduction to the Work-in-Progress Study
How can we utilize our research knowledge to impact our methodology as educators and change the perceptions of science, technology, engineering, and mathematics (STEM) and who belongs in STEM careers? Some states have adopted the New Generation Science Standards (NGSS) for k-12 public schools, which specifically require teaching children the engineering design process.1 Besides creating a better product, the standards say the design process is relevant because the process begins with defining the “human problem” (empathizing) to connect to the real lives of all. The assumption is if students can connect with the “human problem,” they will identify with and have interest in STEM. But no instructional methodology on how to teach empathy is stated. Will inserting a “human problem” in instruction instill empathy and connect to a student’s real-life? Would doing so improve student interest in STEM? What are the hurdles we would face? The focus of this paper is how infusing empathy into the design of lessons would influence student interest in STEM, STEM careers, and a sense of belongingness in STEM.

In January of 2016, we began a mixed methods study on student interest in a demographically diverse urban middle school that informed the research in this paper. One part of the mixed methods study included a nine-month case study of an all-girls after-school STEM program at the same school.2 The results of the study indicated interest in STEM, STEM careers, and a sense of belongingness appeared to increase for all the girls after exposure to empathy-infused STEM lessons. The question we wanted to pursue next was, “Would these lessons have a similar impact on students in a different program composed of both boys and girls?”

In the fall of 2016, a study of a mixed gender, nine-week, after-school science program at another demographically diverse urban middle school was initiated. Over a nine-week period, this study utilized nine of the twenty-eight lessons of the original nine-month long all-girls program. This work-in-progress paper conveys the preliminary results of the coordinator (teacher) interviews, student open-ended surveys, and researcher observation field notes. In process is the analysis of photos, and the audio- and video-recordings from the observations. The larger study also includes Likert scale surveys, and student interviews.

The preliminary results indicated these empathy-based lessons may have a positive and rewarding impact on interest and belongingness for both genders. This study also unveiled the complexities and challenges of infusing engineering empathy into middle school instruction, which has implications for both classroom pedagogy and educator professional development.

Background
Girls, women, and other non-typical STEM-bound students remain under-represented in education and within the workforce of STEM. Although the needs of women and all other non-typical STEM-bound students are uniquely different, in this paper we discuss their needs with one broad stroke. Numerous studies suggest affects, like interest, belongingness and self-efficacy, rather than ability, are responsible for the overall lack of diversity in advanced degrees or employment in STEM fields.3 Other studies indicate girls are interested in STEM, but primarily in life sciences and other empathetic, social topics rather than the more analytical areas...
like physics, computer and mechanical engineering.\textsuperscript{4} This is problematic since physics, for example, is considered a gateway to engineering.\textsuperscript{5} Although armed with this knowledge of what girls prefer, little has changed in the numbers of females who stay in STEM. Additionally, the focus on analytical areas and the exclusion of empathetic areas of focus is what partly defines engineering as a limiting culture.\textsuperscript{6,7} How do we begin to change the culture and perception of engineering toward one that is inclusive and empathetic?

Many researchers are studying what might influence a change to the multi-layered intersections of STEM careers, classrooms, content, and culture with complex constructs like interest, motivation, attitudes, self-efficacy and identity. Some researchers have begun deconstructing these complex constructs through study of high school students’ identities and their sense of belongingness.\textsuperscript{7} Others optimistically suggest framing engineering as a caring profession at the elementary school level.\textsuperscript{8}

The recent idea of importing a sense of empathy and grounding it with social work (a socio-technical perspective)\textsuperscript{9} in engineering practice and college education may apply to k-12 pedagogy, where no extant literature exists. This “marrying” of the social and technical aspect of empathy is the perspective we take in this study.

**Research Questions and Objectives**

Our research question is how does an after-school program focused on empathy-based lessons influence girls’ and other under-represented student STEM interest, STEM-based career aspirations and a sense of belongingness in STEM? We study how students define and experience empathy and belongingness to help educators develop curricula to improve student situational and personal interest. Our grand objective is to make the world a better place through a diverse socio-technical STEM culture, accessible to all.

**Theoretical Framework**

This case study, framed by empathy and the belongingness component of identity, is seen with a transformative perspective.\textsuperscript{10} I chose a transformative perspective because I want to change the way people behave, not just think, toward under-represented STEM bound students, particularly girls in engineering; how policy is written; curriculum is designed and taught in schools; how businesses interview and maintain diversity in their workforce; and how engineering is perceived. The paradigm for this study is socio-cultural interpretivist. Or to say, the intent is to “study ‘things’ within their context and consider the subjective meanings that people bring to their situation.”\textsuperscript{11}

As interest develops over time through knowledge, activities, engagement and social support, it can evolve from situational interest to a more committed personal interest.\textsuperscript{12} This study considers the influence of empathy on interest development and a sense of belongingness. Identity theory says belongingness is important to creating role identity,\textsuperscript{13} and that identity and interest are closely connected.\textsuperscript{14}

**Empathy.** Research indicates girls’ empathic preferences may be socially influenced.\textsuperscript{15} Empathy is identified as an important characteristic for acquiring 21\textsuperscript{st} century design and engineering skills.\textsuperscript{8,16,17} Empathy can be emotional, descriptive, or applied (such as, engineering...
empathic design). Research indicates those who excel in more analytical areas (engineers) are less capable of the emotional aspect of empathy. Other studies indicate engineering educators and practitioners may lack explicit attention to empathy and caring, and a need to prioritize the understanding and the role of empathy.

One method of improving the inclusion of empathy in STEM is to fully utilize the existing Stanford 4D Design Thinking Process Model (Fig. 1.). This model begins with empathizing. Many other models utilized in engineering practice and in k-12 instruction omit empathy as a first step. Stanford defines empathizing as “work to fully understand the experience of the user for whom you are designing...through observation, interaction and immersing yourself in their experiences.” Emotional learning, which includes empathy, reinforces the significance of individual lives and improves students’ achievement on academic tests.

Fig. 1. Stanford 4D Design Thinking Process Model

**Belongingness.** Engineers from under-represented groups identify a sense of belongingness (and recognition) as important success factors. Recognition and belongingness are closely associated and will be studied together in this study. To be recognized is defined as to “acknowledge the existence, validity, or legality of.” To belong is defined as “fit (of a person) in a specified place or environment.” Maslow’s hierarchy of needs lists belonging on its third tier. Humans need to belong, not just to succeed, but to survive. To feel belongingness requires not only the ability to perform the skills required of a member of the community, but also to be recognized by the community as a skilled member. Being accepted is a difficult task in the highly-gendered culture of engineering. Recent research indicates that belonging and recognition influence achievement and interest, especially for girls and women. The preference for empathetic work appears to help women maintain their identities, not merely adopt the identities of men.

**Interest.** The National Research Council identifies interest as a critical factor in predicting future engagement in STEM. Studies focused on girls in STEM indicate girls lack interest, not ability. Interest may have a larger influence than academic achievement on choice of STEM as a career. Fewer and fewer students have been choosing to major in scientific fields at secondary and university levels. In some areas, such as mechanical and electrical engineering, the number of women has declined since the 1960’s. Research indicates STEM interest declines with progression in school, with a significant drop by the end of middle school, and greater decline for girls and minorities. Some report girls’ and minority interest begins and remains lower than boys.
Interest is defined as: (1) a feeling of wanting to learn more about something or to be involved in something or, (2) a quality that attracts your attention and makes you want to learn more about something or to be involved in something. Hide and Fenninger define interest as a multi-dimensional progression of four levels beginning with initial situational, or temporary, interest and moving toward a more lasting, stable and sustained form of persisting or personal interest. A characteristic of personal interest evident in observed behavior or verbal expression is a student’s intrinsic readiness to acquire new domain-specific knowledge and to explore an idea or concept about the object of interest meta-cognitively. Taking work home, asking to borrow a book on the subject, or teaching peers are examples of personal interest. We followed the Hide and Fenninger model in our study and analyzed observed behavior and student self-reported interest through written and verbal indicators.

Methodology
The research was conducted one day a week for nine weeks, within the sixth-grade class of a middle-grade after-school science club program sponsored by the state university through the local 4-H. The school district had a disproportionate percentage of recent immigrants and under-represented minorities. Thirty-eight (38) students (fourteen girls) registered for the sixth-grade class. Approximately fifteen students attended class regularly.

Participants. Any student in the science club could participate in the research. Of the twelve students who provided study permission, five were boys. Of those boys, two were Caucasian but one was an Eastern European immigrant, two were African-American and one was Hispanic. Of the girls, one was African-American, one was mixed raced, two were Asian, two were Hispanic, and one was a Pacific Islander. All student participants were identified by self-selected code names. Two 4-H coordinators facilitated the program lessons. Miss Wonderland (code name) was a female Caucasian in her early 30’s, educated as a special education teacher, and had facilitated 4-H classes for four years. Miss Sweet (code name) was a female of Pilipino descent in her mid-20’s and a recent STEM graduate. The third coordinator was a post-doc in science education conducting longitudinal research at the school. She did not attend every lesson.

Methods
To address our research questions, we utilized qualitative methods, often called interpretative phenomenological analysis (IPA) in engineering education, so we could best unveil and understand how students responded to empathy-infused lessons. Instruments included open-ended student surveys, lesson observations and coordinator interviews.

Observations and interviews. Classroom observations and coordinator interviews followed a protocol (See Appendices A and B for sections of both). The observations focused on both coordinator and student behavior and dialogue. Did the coordinators talk about empathy? Did student interest change through different genres of participation (“hanging out,” “messing around,” or “geeing out”) and pronoun evolution (from “them” to “me”). Were students and teachers able to connect and transition from feeling empathy to empathic design? Interview questions focused on how coordinators perceived the lesson instruction, lesson ability to convey empathy, student and coordinator understanding of empathy, impact of lessons on student interest and student sense of belongingness.
Student surveys. Open-ended student survey questions were on STEM topics, careers, belongingness and empathy. The survey was conducted at the beginning and end of the nine-week program. See Appendix C for a section of the survey.57

Lessons. All the lessons were borrowed from various STEM websites with a “STEM Save the World” focus and followed the Stanford Design Model (Fig. 1.). Lessons required both individual and group work, and were intended to evoke comments about empathy, interest, and a sense of belongingness. At their discretion, the coordinators often made changes to the lessons the day before class. All changes were documented. See Appendix D for a typical lesson.

Data analysis
The overall coding approach most closely resembled what Saldana describes as in vivo, descriptive, and emotional.58 Also utilized was a constant comparative method of data analysis comparing “one segment of data with another to determine similarities and differences.”59 Documents were coded a priori for the three constructs of empathy, interest, and belongingness by evaluating words, emotions, and emotional intensity.60 All documents and artifacts were simultaneously open-coded for concepts outside of the a priori set to include additional concepts or themes that emerged.

Preliminary Results
Because this is a work-in-progress some of the overall, or more subtle evidence may not yet be unveiled. Changes in pronoun usage were intended as an indication of interest but the lack of structure, high noise-level, and student resistance to writing made it difficult to measure.

Open-ended student surveys. Preliminary results of surveys of the twelve students indicate students had a better sense of engineering’s breadth and empathy after the program. Two of the more verbally expressive students were John Cana and Sapphire. John Cana, a Caucasian boy, most comfortable in science, math, and other “nerdy classes,” only worked with boys. John was asked, “What is engineering?” John’s initial response was “building stuff,” but he later indicated an added sense of empathy. “It is about thinking about building something and thinking about who you’re building for.” Sapphire, an Asian girl, analytical and confident, often doodled in class. She first indicated, “Engineering is about making stuff that works.” She later indicated, “Engineering is more than just building. It can also be about art/creativity about the design.” Sapphire expanded her perception of engineering from building to art, creativity and design, which more closely related to her doodling.

When asked if there was a specific activity of interest in STEM, five of the twelve students were more interested in STEM after the program. Five others were already broadly interested in STEM, as one might expect from students who self-selected into a science club. Another specific example of a student response came from Naruto a very quiet Hispanic boy. Naruto originally said, “exploding things,” but after the program said, “In technology I like it because you get to make apps and other cool things. Also, engineering because you get to make things like robots.” Naruto had a broader interest in STEM after the program.
Students were also asked if girls belonged in engineering. Interestingly, all post responses were positive. In fact, of the five boys, three responses were positive in the pre-survey. For example, in both the pre- and post-survey, John Cena indicated, “They can do the same things.” Sapphire had no answer pre-survey, but post-survey indicated, “Everybody can do anything and sometimes girls do better than boys.” Caroline, an African-American girl, often worked alone and appeared to process her learning meta-cognitively, appearing to ponder, then making changes to her design. She originally indicated, “Men and boys aren’t just [sic] the only ones who can make change.” After the program, Caroline’s response was “I know my ideas are worth sharing.” Caroline directed the question of belongingness in engineering to herself.

The open-ended surveys also indicated a greater sense of belongingness and empathy (social consciousness) after the empathy-based program. These results held true and may be important for both genders. When asked how engineering makes the world a better place (empathy), Naruto had no response pre-survey. His post-survey response was “by helping people.” Hamburger (code name) is a mixed-race girl who first indicated, “making a fuel-efficient vehicle.” In her post-survey she answered, “Prosthetic legs have made life easier for people who don’t have legs.”

When asked for reasons why they joined after-school clubs, eight of the twelve students (three of the five boys) originally indicated “I feel I belong,” and/or “My friends are there,” and/or “My friends like it there.” When asked, post-survey, what the most important reason was for joining their after-school clubs all but two students answered either “I belong,” “I do well,” or “We do important stuff.” Ironically, the two most studious girls replied because “It is fun.” Interestingly, three of the five boys indicated their reason for joining was “It helps people,” while girls favored the answer “We do important things for the future (four of the seven).” After the program these boys were more interested in helping others while the girls were more interested in the future.

**Coordinator interviews.** Preliminary analysis of interviews revealed that 1) all coordinators believed inclusion of empathy was important for students to understand STEM’s application to the real world, 2) all coordinators were enthusiastic about the lessons and believed that the lessons were empathy-based, 3) classroom coordinators believed they scaffolded empathy in the classroom but the post-doc did not, and 4) none of the coordinators were certain the students grasped the empathy concept well. The coordinators said, to different degrees, that they thought the students understood the design process and empathy but that the students could not describe well or convey quickly the process or what empathy meant to engineering design.

When asked about empathy in the lessons, Ms. Wonderland indicated empathy was present and was taught by the coordinators. “Yes, I do believe the lessons were empathy-based.” She further indicated she scaffolded empathy in the lesson but was unsure if students understood empathy. “We took time each week...But I am not sure the students were able to fully process that each time and I'm not sure I saw a difference in girls versus boys.”

Ms. Sweet’s also believed she scaffolded empathy. She believed the students understood empathy but needed prodding. “They didn't always think about it right away and I would have to hint some things but automatically they would relate it to a real-life structure, tool, or situation...I would ask why that was important and they would put some thought into before replying and
some said, ‘to make sure people are healthy and their hearts are healthy’ or ‘if something is wrong they can help people get better.’ They soon understood that everything being done was in thought of how to help [in consideration of helping] other people.”

Ms. Wonderland and Ms. Sweet both believed the lessons increased STEM interest. Ms. Wonderland’s evidence was continued student sign-up for the program and lesson-specific interest. When asked in a follow-up e-mail, Ms. Wonderland wrote, “I am saying on a specific lesson I did see student interest increase but I can’t say overall. Like in the Chairlift Lesson, the kids were very engaged.” Ms. Sweet’s evidence of the empathy-based lessons influencing student interest was more general. One example she gave was a student response to a future career question. Ms. Sweet indicated, “I saw some changes in attitude...asking them ‘what do you want to do when you grow up? One student told me he wants to be a professional basketball player, but eventually will retire and find a cure for cancer.”

The post-doc researcher, Ms. Thinker’s (code name), response to whether students understood empathy was, “I don’t see how they [the students] don’t understand it better, but I still think that they [the students] just can’t articulate it, so I think maybe it’s more embedded in the way they [the students] think about it, but I don’t think they [the students] can talk about it still.” Her concern revolved around the lack of framing/scaffolding of empathy and the design process in the lessons. “We, [the coordinators], should have provided examples of places people couldn’t get, you know, [examples of] how do you think this would make somebody feel.”

Ms. Thinker spoke about the lack of connection between what students are taught “empathy” means versus “empathy for engineering design.” She said, “There’s a focus on kindness and all these things that the school gives them messages about...but I think that empathy in design is usually on a different level.” This comment suggests a need to further investigate the age appropriateness or multiple definitions of empathy.

Observations. The preliminary results of one lesson were taken from the Observation Protocol notes for Heart to Heart: Building a Stethoscope. Appendix E illustrates actual statements by Caroline and John Cena. Caroline was already speaking in the first-person “I” before the lesson and John evolved from the pronoun “you” to a first-person pronoun “we” by the end of the lesson. Evolving pronoun usage may reflect evolving interests. Exhaustive analysis of the audio/video data of all lessons must be completed to confirm any overall trends of interest evolution.

Appendix F illustrates examples of behavior by Caroline and John Cena. Carolina, was looking at the lesson worksheet by herself at the beginning of lesson. Others joined her and she completed the stethoscope design. She ended the lesson by creating a second design (a headset) with her materials that she asked to take home. Caroline’s behavior suggested a move from “messing around” to “geeking out,” or from transitional to personal interest. John Cena began by talking with other boys about weekend plans interspersed with questions about the lesson, then moving away from those boys to work on his design with another boy. Both boys focused on their work and designed and tested their products. John Cena’s behavior suggested a move from “hanging out”/situational to “messing around”/transitional interest. John had no interest in other designs or taking his work home. The participation genres suggest a move from “hanging out,”
to “messing around,” to “geeking out” and reflect an evolving interest for these students.\textsuperscript{55,56}

Below are Fig. 2, a photograph of John Cena and Fig. 3, a photograph of Caroline in participation genres “messing around” and “geeking out.” Both students began class “hanging out,” that is, talking about non-science class topics.

| Fig. 2. John Cena “messing around”—enjoying his stethoscope. | Fig. 3. Caroline “geeking out”—changing the design and taking it home. |

**Discussion**

The research question for this mixed gender case study was how does an after-school program focused on empathy-based lessons influence girls and other under-represented student STEM interest, STEM-based career aspirations, and a sense of belongingness in STEM?

The open-ended survey and observation field notes indicated that students felt a clear sense of belongingness and that belongingness was an important part of the program to them. This sense of belongingness improved after the nine-week session regardless of gender. Changes in participation genre and pronoun usage from third to first person were noted in observations, suggesting students may become more interested during the empathy-based lessons. However, exhaustive analysis of the photos, audio, and video data of all lessons must be completed to confirm any overall trends of interest evolution. The open-ended survey and observation field notes also indicated students better understood the meaning of STEM and STEM career options after the lessons than before. However, student interest in STEM careers may show greater improvement if STEM professionals or mentors were part of the program. In some cases, student answers reflected no improvement because students were already positive at the pre-survey stage. This may be because students who come to the after-school science club already feel they belong and are interested. Many have attended the class before or other STEM after-school classes.

Students struggled with writing, drawing and expressing themselves in sentences during the program. Some of this hesitation may be due to what Ms. Wonderland said were the “high number of English second language and attention disorder students in class.” After the second
lesson, Ms. Wonderland reduced the amount of student writing to only the Empathize and Share questions. All coordinators believed they covered the design process repeatedly. But whole-class observation field notes, unlike coordinator recall, indicated the design process was only reviewed in the first two lessons, in both cases by this researcher rather than a coordinator, and mentioned once by Ms. Wonderland at the onset of class. Only the post-doc, Ms. Thinker, said instruction was inadequate and missing scaffolding of the design process. She suggested movies, role modeling of disabled people, or other interactive methods of instruction were needed to help students better transfer knowledge of empathy to empathic design.

Interestingly, at the end of the final lesson, *Reusing Trash*, all students presented their empathy-based design in front of the class. Students were more than willing to go the front of the room and present their products. In fact, they vied for who would go first. They appeared comfortable communicating their thoughts and opinions in these presentations. Students’ ability to speak about their designs and the contribution of their designs to the environment showed progress in understanding the design process and empathy. More presentations, and other interactive student participation, may alleviate some of the language and cognitive struggles.

The previous study was a nine-month program in which two days were spent on each lesson. More learning time is likely needed for each lesson as well as for the overall program than available for this study. A less than two-hour session with a dinner break in the middle, once a week for nine weeks, appears inadequate to complete the lesson steps and apply empathy. Some students came or left after the dinner break. Many students did not answer the Share question in the design worksheet. No time was scheduled for students to reflect and they were usually in a rush to catch their bus. Consequently, students were often unable to complete the entire design process, making it difficult for them to learn the entire process. Coordinators often skipped to the Building phase, at the expense of planning and reflecting, using the more hands-on activity as a classroom management tool. This hesitation to stay focused on the process has implications for instruction. The omission of these steps not only undermined the importance of empathy but also of the value of failure to successful design. This situation might be mitigated had the coordinators and researchers spent more time collaborating on preparing for the lesson to determine what coordinated scaffolding efforts would help instruction.

From the coordinator interviews it was evident that coordinators believed empathy should be infused into lessons. They were less certain how to connect emotional empathy to engineering design empathy and how to assess student progress other than through student self-reporting. Examples from the coordinator interviews addressed the need to clarify the concept of empathy, especially engineering empathy in instruction, and for facilitator professional development. Both coordinators and students lack training in empathy and its relevance to engineering design. Coordinators were consequently lacking confidence in any instructional methodology to scaffold student learning of those connections. Although professional development and curriculum changes seemed necessary, some minor improvements, like varying methods of assessments and instruction to increase student participation may be logical first steps.

**Limitations**

Our small participant size of twelve students, the lack of consistency in instruction and classroom management limited the amount of data collected. Additionally, results may be biased
because students self-select into the program and may already have some interest in STEM. Because most of our students are “under-represented” more study is needed to determine how differences, other than gender, impact interest. In the preliminary results, the influence of empathy-based lessons on student understanding of empathy, sense of belongingness, and STEM interest seemed to be gender neutral. We were surprised when we asked, “if girls belong in engineering” that the answer was positive for both boys and girls. In fact, the students seemed surprised at the question. This reaction has not been the case in our previously mentioned study. Perhaps the students are influenced by school specific factors. Nevertheless, how empathy is defined deserves further study.

Lastly, results are based only on coordinator interviews, student open-ended surveys and observations. Complete analysis of observation photos, audio- and video-recordings is in progress. Complete data may inform and change these results. This study is part of a larger study that includes student Likert-scale surveys and interviews. The piece of analysis yet to be completed may provide additional insights (i.e., connecting to school-wide mathematics, science and STEM interest survey data).

**Implications**

Our hope is by highlighting empathy in k-12 STEM curriculum, especially in analytical sciences, the perception of engineering will change to a more welcoming culture where girls and other under-represented students will feel they belong and the status of the caring sciences will be elevated. Educators are challenged to present the empathy-based design process in an integrated and student-centered manner, and to provide effective instruction of empathy and empathic design before we can influence student interest and impact perception.
References

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Appendix A
Observation Protocol

Infusing Empathy into Engineering Design: Supporting Girls’ Interest and Sense of Belongingness

Observer: ____________________________
Date of Observation: ____________________________
Grade: 6 7 8 ____________________________

DURING THE LESSON-focus on any conversations, behaviors or groupings related to interest or belongingness of girls versus boys.

1. What is the coordinator doing?

2. What are the students doing?

3. Within the lined sheets observe students’ participation behavior for signs of “hanging out,” “messing around,” or “geeking out” by noting their groups size, activity and nature of the conversations. Identify students.

4. Within the lined sheets observe students’ language, notably pronoun usage, STEM courses or career comments. Identify students.

LESSON FLOW RECORDING SHEET
Take notes describing the activities of the coordinator and students occurring during the lesson period. Provide a time stamp in the “Time” column to correspond with the events.

AFTER THE LESSON
1. Did the lesson follow the 4D design process? How or how not?

2. Did the coordinator open/close the lesson with empathy?

3. Main activities that occurred during the lesson period including the amount of time devoted to each.
Appendix B
Coordinator Interview Protocol

1. How would you describe STEM?
2. How would you describe engineering?
3. What interested you in this program?
4. What are your main goals for students in this program, and what evidence, if any, do you have that these goals may have been met?
5. Do you see a difference in their interest in STEM since the beginning of the year? girls versus boys?
6. I wonder if you saw any kind of increase or less messing around and more doing the work.
7. Can you give an example of something that comes to mind of what they are interested in?
Appendix C
Open-ended Survey Questions

The Future

1. **What** do you want to be when you grow up?

2. **Why** do you want to be that when you grow up?

3. I think girls **belong in engineering** because_____________________________________

4. An example I know of **how engineering makes the world a better place**
   is____________________________________________________________________

5. I know someone who is an engineer.  Yes or No (circle one)

6. Please tell us how this person is related to you. For example, is this person your friend or is it your mom or dad?
LESSON NAME: Live Like an Animal
SOURCE: eGFI-For Coordinators
BIG IDEA OR CONCEPT: STEM Saves the World!

DAY ONE:
Background: When engineers use examples from the natural world to influence their design they call it “biomimicry.”

Real World Connection: The 2008 Beijing Olympics main stadium is an example of this type of design. Architects and structural engineers who built it designed it to look like an enormous bird’s nest.

Intro to lesson: When you were younger, did you ever build a fort out of pillows, a blanket, cardboard, or tree branches? Can you think of an example from nature that resembles your fort? What kind of animal structure is similar? (Bats or bear cave, bird’s nest?) What are some advantages of the examples given? (I.E. lightweight, strong, sheds, protection).

Activity: In self-selected groups of three to four the girls are going to design a human structure based on an example from the animal kingdom they pick. The animal will be researched for ways that animal finds/builds their own shelter. Using that information, the girls brainstorm ideas and design a human structure that incorporates some of the useful features of the animal shelter and sketch and model to the sketch their structure with dimensions and identify needed material.

DAY TWO:
Intro to Lesson: Ask the girls, “Why do you think an architect or engineer would model a building or other structure to the animal and natural world? How do you think you might feel about biomimicry if you were the animal?”

Activity: The girls will recap this week’s STEM challenge, present their design, discuss what was improved and identify any inspirations.
Appendix E
Pronoun Usage Observation Data

*Building a Stethoscope: Heart to Heart Lesson*

<table>
<thead>
<tr>
<th>Third person (They, it, he, she, them, him, her)</th>
<th>Overall interest rating</th>
<th>You First person (we, I, me, us, my, ours, mine)</th>
<th>Provide number of Pronoun Usage Identify the students. Taken from artifacts and conversations in class</th>
<th>Student</th>
<th>Student</th>
<th>Student</th>
<th>Student</th>
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<tr>
<td><strong>Before lesson</strong></td>
<td>During Survey, Sapphire said, “I love science,” It explains so many things! (1&lt;sup&gt;st&lt;/sup&gt;)</td>
<td>Group lots of what are “we” going to do this segment. (1&lt;sup&gt;st&lt;/sup&gt;)</td>
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<td><strong>During lesson</strong></td>
<td></td>
<td>John Cena said, “you need it because it helps you find if something is wrong.”</td>
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<tr>
<td><strong>After lesson</strong></td>
<td></td>
<td>John Cena said, “we failed, so we could do everything better.” (1&lt;sup&gt;st&lt;/sup&gt;)</td>
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Appendix F
Participation Genre Observation Data

Building a Stethoscope: Heart to Heart Lesson

<table>
<thead>
<tr>
<th>Participation Genre</th>
<th>Overall interest rating</th>
<th>Before lesson</th>
<th>During lesson</th>
<th>After lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Many students are loud and running around room. John Cena is talking with other boys about their weekend plans.</td>
<td>Students (John Cena and Base Alex 8) have left talkative group of boys and started working together on the lesson. Caroline is focused on the empathy worksheet.</td>
<td>Caroline decides to bring her design home.</td>
</tr>
<tr>
<td>Before lesson</td>
<td>1= situational interest or “hanging out.”</td>
<td>Three groups are sitting at their desks and looking at work.</td>
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<td></td>
<td>2= transitional interest or “messing around.”</td>
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<td>3= personal interest or “geeking out.”</td>
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