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Board 236: Children's Identity Conception in Engineering Activities in the Home Environment

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Children’s Identity Conception in Engineering Activities in the Home Environment

Abstract
The purpose of this study was to examine identity formation in young learners through engineering education. This was sought by means of understanding children’s perception of their identity as an engineer after engaging in engineering design processes and practices in their home environments.

The methodology for data collection was through post-program participation interviews with children. The interviews were conducted with thirteen children between the ages of five and ten, who completed at least four researcher-developed engineering tasks in their home environments with a member of their family, typically a caregiver. The time engaged in each kit ranged from approximately 30 minutes to 3 hours. The interview questions revolved around how these children viewed engineers, and engineering, as well as how they viewed themselves and how the program changed their views and interests.

The results suggest that participation in an engineering program in home environments has changed these children’s sense of identity in a variety of ways; how they viewed their ability to carry out engineering activities, their potential career trajectories, how they viewed engineering as a field, and how the program affected their interactions with their family. The significance of this study points to the benefits of introducing engineering tasks with children at a young age.

Introduction

Although the number of women in STEM has increased in the years between 2011-2021 [1], engineering is considered a male-dominated career [1], [2]. This poses the question of how to tackle the gendered view of the profession, making engineering a viable academic and career option for both, men and women. One solution can be through identity recognition, especially at a young age [3], [4], where establishing a child’s identity and sense of self, as well as their interests, can affect their future career trajectories. Hence, the purpose of this study is to look at children’s identity and sense of self, after engaging in engineering activities in their home environments.

Literature Review

Identity is a complex concept that has been examined and defined in a variety of ways. Identity is a term used to describe a person’s sense of self in relation to groups, or in relation to content, and it looks at the developments in a person’s thinking, their decision-making, and their responses to challenges [5]. Renninger [5] also argued that a person’s identity or multiple identities are not stagnant and can be developed through interaction, and intervention, beginning at early childhood. On the other hand, Bilgrami [6] made a distinction between a subjective and an objective aspect of identity, where the former is about how you view yourself, while the latter is about how others view you, in terms of your social and biological facts. The latter was referred to as recognition by Hazari et al [7].

Gee [8] identified four different ways of looking at identity, through the processes of *nature-identity, institution-identity, discourse-identity,* and *affinity-identity.* These processes respectively relate to identity by the nature of humans, identity by status in society, identity by merit and recognition by others, and identity by the experiences that have been had within "affinity groups", meaning groups with whom one shares practices or culture (p. 105). Gee [8] argued that the last of these is the most common, but all of these processes could also co-exist. Additionally, Gee [8] considered that having a relationship with the larger group (family for example) links identity to interactions, which in turn can result in changes to one's identity. A good example that he utilized was that of *charisma*. While charisma is an individual trait, it can only exist and be recognized as such via interactions with others. In STEM research in particular, the construction of identity is seldom considered in interaction with others [9].

According to Harter [10], early childhood is an important phase of identity development as children tend to have positive representations of themselves that are free of comparisons to others and free of self-evaluations. This sense of self shifts by middle childhood, including comparisons of self and abilities to others, potentially resulting in dual descriptions of themselves in terms of abilities, and emotions.

For the purposes of this study, identity is viewed as the sense of self that children have, especially after engaging in engineering activities, as the hypothesis is that engaging in engineering activities at home can positively affect these children, and the way they view themselves, their abilities, and their interests [4].

Methodology

The data were collected through post-program interviews with families who participated in a larger grant project. Families were recruited through flyers, social media posts, and emails from teachers within local schools and community organizations (e.g., libraries). Families engaged with the program for one academic year. The program was an at-home engineering project, where families completed researcher-developed engineering kits. These kits provided families with instructional guides, one for the parents and one for the child(ren). These instructional guides were not meant to give the families a step-by-step guide, but rather, a chance to go through the different stages of the engineering design cycle, conduct *research*: looking at products that already exist; *plan*: thinking how to build; *create*: putting the prototype together; *test*: try out prototype; and *improve*: redesign your prototype.

In total, there were 12 kits for the families to choose from, and each family selected six kits. One example of a kit is the Toy Hack, which is a way to recycle and repurpose toys. More specifically, families were tasked with the following engineering task:

> You have been asked by a toy refurbish shop to brainstorm ways to give old toys a second life using electronic parts. Make a prototype that renovates, redesigns, and/or remixes an old toy. The prototype should change the look and feel of the toy, or the toy's role in our life, using new materials.

The kit included an old toy, a motor, LED lights, a battery holder, Velcro dots, a buzzer, and wires. The guide supported families through the design cycle, from research and brainstorming to redesigning. Regardless of which kit these families worked with, the process was consistent, giving them opportunities to be creative and add their own personal spin on these activities.

It should also be noted that as a part of the program, children were introduced to a range of engineers, using what was referred to as an "engineering passport". This passport gives small blurbs on what an electrical engineer or a biomedical engineer might do. It also used stickers to represent each of those, which the children could then use to illuminate which engineer they identified with, through the work they did on the engineering kits that they built. For example, a child would use the electrical engineer sticker if they worked on the Soccer Bot or the Watercolor Bot engineering kits. Alternatively, they would use the civil engineer sticker if they worked on the Paper Rollercoaster kit, because a civil engineer can design a rollercoaster that meets the safety requirements.

These interviews were held with families who participated in the program in its fourth cycle (2021-2022), usually with both a parent and a child(ren), lasting between 30 and 90 minutes. Due to the random nature of the recruitment technique, we had a diverse pool of participating families. Some families were already in the field of engineering but wanted their children to learn about what they do, and perhaps develop their interest in the field. While other families participated in the program as a way for their family members to do an activity together as a unit. For the purposes of this paper, the discussion will be focused on the children's post-program experience.

Thirteen children were interviewed, all were between the ages of five and ten years old. The interview questions focused on the children's perceptions of engineering, engineers, the traits of engineers, and how they viewed themselves in terms of their understanding of those concepts. They were also asked about their level of confidence, comfort, and interest in engineering after having participated in the program. The interview data were analyzed through a thematic coding of the children's responses to the questions which were related to identity. The themes that were identified for each question are introduced in the *results* section.

Finally, and while not all children participated in this mini-activity, they were asked to create a mini-version of themselves as engineers. To carry out this task, the children were provided with cutout figures in the shape of a LEGO person. These figures can be personalized using material that was provided, as well as any additional material from around the house. These representations are referred to as LEGO-Me's [11].

Results

The findings from the interviews are broken down below by theme of question, and its subsequent responses. The questions inquired about the traits of engineers, as understood by the children and the children's understanding and perception of engineering and engineers. Finally, the children were asked to elaborate on the LEGO-Me depictions of themselves, and how that communicated their engineering careers- or lack thereof.

Traits of an engineer

These questions revolved around the idea of reflecting on what it is like to be an engineer, as well as reflecting on what they personally did that resembled an engineer. Embodying these traits and reflecting on them has the function of shaping both, their subjective and objective identities, as perceived by others [6]. The first question was asking about what these children thought the traits of an engineer to be, and the second part of the question was about which of these traits did the children display while engaging with the kits. A discussion follows below of the more prominent responses.

Realistic Thinking. Realistic thinking was one of the traits that was recognized as important for engineers. Engineers do need to be realistic when thinking about their design, what it can actually do, and what materials are available. To this effect, Aurora thought that "realistic thinking" is important for engineers and elaborated that that was her experience with the Paper Rollercoaster kit. She said that she: "had to restart a few times because I didn't cut the index cards correctly, Because I was snipping some spots, so I could bend them upwards. And then [when I] went to connect, and I was thinking, the pillars [or supports] weren't really working for me, so I thought the pillars would be too hard, and I was thinking Okay, so I can't do the pillars they're not stable enough, So what if I just tape it to the wall. I feel that was more realistic because it would be a lot more stable". Here, not only was Aurora realistic in considering what she can do with the design and the material, but she also got creative by using the wall for support.

Persistence and Perseverance. These two qualities are important for engineers, especially when the engineers are dealing with experiences of failure and frustration. Overall, these qualities and experiences are essential elements in going through the engineering design cycle [12]. When asked to provide an instance of a time she persisted, Sarah said: "the first kit I did, the paper roller coaster. That one was, it didn't really work well, because the marble kept rolling off. And I didn't know why. But after that, I was looking at the whole thing. And then I saw that the sides weren't up all enough. It's because the marble is going down fast. So it goes side to side. So it probably go off. So we made the sides a little bit bigger. Taller".

According to Aleena and Atalia, Perseverance is an important trait because "it'd be hard to be someone who builds and creates if you tried to design and it fails and you're just like, well, that didn't work, time to move on".

Efficiency. Being an efficient engineer means being resourceful, not only with the material available at hand but also with time. Amethyst thinks that one of the traits she possessed that would help her as an engineer was being "done faster". On that, and when working on the Trendy Tennies engineering kit that required creating a shoe design for a given character, she said: "I use(d) a tennis ball. Because that was about the size of [Olaf's] foot. So I put that in there to see, that was a good size and four rounds". What Amethyst meant was that instead of wasting her time with figuring out the size of Olaf's foot, she found a similar item in her surroundings (i.e. the tennis ball) to approximate Olaf's shoe size, saving herself time.

Working with Others. Collaboration can come in a number of forms, either family members, as was the case with this family engineering program, or it can be other team members in a business environment. Having the ability to work in teams is also important as engineers do work with others and need to also collaborate with others [13]. For Audrey, working with others was important because "when you can't know to ask, it would be hard to work on your project".

Be okay with Failure. Failure is an inevitable experience when prototyping, and testing, and should not discourage an engineer from pursuing their goals and visions [12], and according to Max, an engineer needs to be okay with failure because: “you can learn from your mistakes”.

Intelligence. Being intelligent and smart are some of the traits that came up repeatedly. While the concept of intelligence is highly subjective and could be interpreted in a number of ways, it could be generally identified as the ability to provide a solution to a *new* problem on the spot [14]. According to Eliot, being intelligent was important because: “I know what to do next. So it won't fail and knowing that if you fail, you'll know that not to do that thing, and you'll keep going”.

Some of the other traits that the children highlighted as important for engineers are creativity, planning, brainstorming, experience, and patience, which shows how these children have internalized the engineering design cycle, thinking of those steps as characteristics of engineers.

Knowledge and Interest in Engineering

The children were asked a number of questions, and they had to give their answers on a numerical scale of 1-12, where 1 meant “not interested at all” or “do not know”, and 12 meant “super interested”, or “loved it”. Following is the list of the questions and how the children rated themselves accordingly. Generally speaking, the children’s beliefs about themselves, as well as their interests, affected their participation [7]. Not only did the children’s rating reflect their interest level, but it also highlighted how they viewed themselves as engineers.

How interested are you in engineering? As expected, the children’s interest after participation in the program increased. Responses to this question ranged between 6 and 12. In talking about the shift in their interest in engineering, Aleena and Atalia, who rated their interest at 9 said that: “I really like engineering things. I like to create stuff”.

Do you feel like you understand what engineers do? This question was based on the children’s interaction with the kits the and engineering passport. The response to this question ranged between 3 and 12, and even when children rated themselves low, it was because they realized the vastness of the field of engineering. Aurora, who rated herself on the lower side of the scale at 3 said: “I learned engineering is literally in everything like this pillow. Like every everything right around us, the whole world has really been engineered. I think it's not I don't have very wide range of understanding of engineering, because I have been doing this for a while and everything has been engineered like an engineering is in everything…I could learn more basically”.

Eliot, who rated his understanding at 12, said that the one “cool” thing he learned about engineers was that: “they can really make whatever they want. If they like, plan out and draw”.

Aleena and Atalia, having rated themselves at 9 and 6, said that: “There’s Different kinds of engineers like I knew are there different kinds of I didn't know that was like, tech engineers...I thought there were engineers who invented stuff, engineers who made it, and engineers who made it work, I didn't know that there are like engineers who specialized in this and specialized in this.”

Finally, Max, who rated his understanding at 12 said: “I know that engineers engineer like how to help things. If, someone's really old and they need a wheelchair, and someone isn't always there to push them. They could make something that they could push by themselves”.

How comfortable are you with failure and frustration? This question received a wide range of responses, varying between 3 and 12. Since failure and frustration are intricate elements of the engineering design cycle, we wanted to know how these children dealt with these two negative experiences. Dealing with failure and frustration can reflect how the children saw themselves. For example, Sarah, rating herself at 7, thought of these two components as a way to see what went wrong. To this effect, she said: “I get a little bit frustrated, and I'd see what I did wrong. but I'm not totally okay with it [failure] because I just get a little frustrated because I did it like a bunch of times, and still don't know what [went] wrong”.

Eliot, rating himself at 6, said that he normally “get[s] mad and figure[s] out how to make it work”. Dealing with failure and frustration in such ways reflected confidence in abilities, as well as thinking of components of the engineering design cycle, such as retesting, shows how the children are thinking and acting like engineers.

How confident are you with creating new things? This question mostly received ratings on the higher end of the scale, between 9 and 12, Having high numbers on the scale reflected how these children saw themselves, and this level of confidence would likely not be possible without the amount of research, knowledge, brainstorming, designing, and prototyping that the children have put into the kits. An example here is of Eliot, who said that the level of his confidence changed: “I felt pretty bad because I didn't think I was really good at it. But I started doing the kits, I learnt that I could build things”.

How do you see or how do you maybe use everyday materials? This question received mixed responses, with the lowest being 4 and the highest being 12. This question is strongly related to the nature of the kits, as they required using recyclable materials from around the house. Max, who rated himself at 12 said that: “we use the recycled box as the home of the doghouse. And then, we also have cardboard as a roof. And then, the vegetable on the thing [plastic containers] that comes in like blueberries. We use it like one of those windows. And we don't use like a bunch of cardboard, but then we use some plastic”. Seeing things differently related to how these children viewed the world, which in turn can potentially lead the children to reflect on their own self and experience differently.

Thinking about working together with maybe your brothers or your parents? How would you rate working together with them? The responses to this question ranged between 5 and 12, but it was mostly on the higher end. In responding to this question, Kaleidoscope reflected on her experience working together with her sister: “building stuff that isn't like just one person's creation, so that we used all our ideas…I think it gives you more patience because sometimes I get really grumpy at my sister like when we worked together on a project and it's just fun and it's kind of there's no point at being grumpy anything because the point is to have fun”. In this sense, Kaleidoscope is positioning herself within the sibling relationship and is taking the lead, seeing herself as a resource, deciding how to handle the situation, as she continues: “sometimes like my sister like didn't really know what to do, or she is kind of shy so she doesn't really speak up when she has an idea. So sometimes she just tries to use my ideas and I think that's like helping her, because if she can come up with ideas on her own then she could use my ideas for her own ideas so that she can practice making their own ideas and like deciding our own decisions in the future".

On the other hand, some of the children appreciated working with their families, like Audrey who said: "I enjoy it. If I did it all by myself, I wouldn't even think of the ideas". While this question did not relate directly to identity, a response like Kaleidoscope not only showed a sense of reflection, but it also showed other traits that are important for engineers, such as "working with others", "patience", and "experience". The experience trait was portrayed in how Kaleidoscope positioned herself as a resource for her younger sister.

Design yourself as an engineer: LEGO-Me's

The LEGO-Me activity provided children the opportunity to create a concrete portrayal of themselves as engineers. Nine children created a LEGO-Me. While the LEGO-Me was not a realistic depiction of themselves, their creations still represented how these children saw themselves, that is to say, their subjective identity.

In these LEGO-Me depictions, the children reflected their personal characteristics, and interests, as well as their career aspirations. On her LEGO-Me, Kaleidoscope [fig. 1] said: "my Lego is this way because I think this is what describes me because I felt like a nature background and [I wrote] *create* in the middle because I like creating things and on the bottom, I drew pictures of engineering tools that I might use to create things and I just colored the arms [in] stripes". When asked about the nature background, she said: "I like nature because I think that animals are all cool and I always think about global warming and how we can stop it so I put that". However, she is not sure what kind of engineer she wants to be, but she wants to be an engineer because she likes to create things in general.

Figure 1

Figure 1. Snapshots of Kaleidoscope's LEGO-Me engineer depiction with some of her personal characteristics

Some of the children tried to make the LEGO-Me's representations of themselves as accurate as possible, like Max, who said in describing his engineer: "So this is my team St. Mark's. And then

I kind of have a baseball bat. I just drew a helmet. And I have my belt", but in responding to how the figure spoke to his identity as an engineer, he said: "I really like baseball I guess… kind of like larger gloves in these to catch like to catch the balls better" when probed further. Finally, he described it as "realistic".

Sometimes, it seemed that the children were influenced by their environment and life experiences in the way they understood and saw engineering; Sarah, in her representation of herself using the LEGO-Me's thought she would be a mechanical engineer. When asked to elaborate, Sarah said: "Maybe because like I could probably learn how to fix a tire or how to change oil because my dad knows how to do that". On the other hand, when Max was asked about the kind of projects he would work on as an engineer, he said: "Maybe making fire extinguishers lighter to carry but can carry more because [if] there's a really big fire, the fire extinguisher is pretty small and heavy. I'd make it lighter, [so] it could hold even more of the thing that's in it". The specificity of this example indicated that it is a decision that was influenced by previous knowledge or experience.

In the LEGO-Me designs, we saw a variety of career aspirations, in the field of engineering, and otherwise. Eliot, [fig. 2] who wants to be an engineer said: "I decided because I wanted to be a software engineer, I can make like a robot thing because that's basically what [a] software engineering is, is for making a game. And maybe a website and stuff like that multiple things and do actionable items, the list of items, total item things and put it on basically". Alternatively, we have Amethyst who created a painter LEGO-Me in response to the prompt, because she liked drawing and crafting. This painter also had a brush and a palette, which shows great attention to detail. When asked how this LEGO-Me represented her, Amethyst said that it matched her hair color, and is dressed in her favorite colors. When further probed for the kind of engineer she was, she said "a designing engineer, kinda like a fashion designer".

Figure 2

Figure 2. Snapshots of Eliot's LEGO-Me engineer depiction as a software engineer

Most of the children created LEGO-Me's that reflected themselves (in appearance, interests, favorite colors/activities, etc.), as shown in fig. 3, where Atalia created a figure that has hair similar to hers. On the other hand, Eliot created an engineer with hair mismatched to his but reflected his career choice -according to him [fig. 2]. It should be noted, however, that fewer LEGO-Me's made a direct connection to the possible future careers of the children. This could be because the children could not make the connection between how they saw themselves personally and in relation to engineering. It might also be that they did not see themselves as engineers. However, their responses to follow-up questions seemed to indicate that they were beginning to think about their potential careers.

Figure 3A Figure 3B

Figure 3. Snapshots of Atalia's LEGO-Me engineer depiction with some of their personal characteristics

Conclusion

The purpose of this research was to examine identity formation in young learners through engineering education. In broader terms, it is argued that identity can be built or diminished by the context of interaction [15]. For example, and as was the case with Eliot, confidence was a big drive for accomplishments. Hence, it can be argued that surrounding the children with a positive environment and exposing them to engineering at a young age can shape their interest and identity, as could be seen in the cases of Max and Amethyst, and this is where the importance of engaging in engineering activities at a young age comes in. This is further argued by Renninger [5], who said that the age and interests of a learner can help in the process of making instructional decisions.

Since self-representation focuses on an individual's development abilities, especially in the context of self-other comparisons [5], further research can look at how the same children who participated in this study were viewed by their parents, and how that has fostered the development and establishment of their identities. Additionally, and taking into consideration the influence of gender differences, a comparison of responses across genders amongst the participating children could shed more light on how gender affects identity formation, especially since, for example, girls who identify as female can express contradictory views of themselves due to socialization [10].

While the LEGO-Me prototype was a representation of how the participating children saw themselves as engineers, one limitation was how the children interpreted the task. Although the interview prompt was not ambiguous: "design yourself as an engineer!" the children were not always able to make a connection to the kind of engineer that they were. For example, in looking at Deena's LEGO-Me prototype, she dressed her engineer in a pink skirt, a butterfly design, and pink shoes, but she could not identify the kind of engineer she was. This resulted in leading questions on behalf of the interviewer, who relied on the butterfly design to deduce that Deena wants to be an environmental engineer. However, this could also be helpful in assisting the children with making connections between what they like, and engineering, which could act as a tool for bridging the gap. Additionally, and starting at a young age, engineering education can help children establish their identities, free of the judgments and influences of others, making positive associations between themselves and the field of engineering [10], especially since identity is important in the determination of a career.

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