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Elementary Students Learn How To Engineer Online (RTP)

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Abstract

The educational disruptions caused by COVID-19 in the spring of 2020 were vast. Schools utilized a variety of instructional methods from paper packets to varying amounts of online synchronous and asynchronous instruction. One Nashville independent elementary school provided lesson plans each day for students to complete, with the assistance of their parents, largely asynchronously. To combat the difficulties encountered by families with two working parents and children frustrated by this type of learning, a zoom-conference based class consisting of three second grade children was created. Each day Monday through Thursday the children were presented a hands-on engineering design challenge that utilized materials found in their homes. The children had not been previously exposed to the engineering design process (EDP). The theoretical framework for this study lies in the areas of engineering identity as well as teamwork and feedback through engineering discourse. The research questions for this study were the following: 1) What are the impacts of teaching the engineering design process online via zoom conference on development of children's ability to use engineering discourse? Are students able to master the steps of the engineering design process? How do students learn to receive and implement feedback from their peers and the teacher over zoom? How is teamwork affected as compared to in-person experiences? 2) If any how do children develop their engineering identity through a series of zoom conference-based engineering design challenges? To answer these questions, data were derived from recordings of the online sessions and observations of student behavior and statements, the PowerPoint slides that were used to facilitate the course, photos and videos created by parents of the students' designs, and interviews with the children. Qualitative data analysis followed an inductive approach. The utilization of multiple data sources allowed for a complete picture of what is taking place during the sessions and how it impacted the children's understanding and practice of the engineering design process. The children became very facile with the EDP and its steps. They looked forward to the design challenge each day, often using it as motivation to get through their required schoolwork before starting the challenge. At times they struggled to give and especially to receive feedback from their peers, particularly when it involved criticism. All three children reported believing that they are an engineer, an indicator of a forming engineering identity.

Introduction

The educational disruptions caused by COVID-19 in the spring of 2020 were vast. Schools utilized a variety of instructional methods from paper packets to varying amounts of online synchronous and asynchronous instruction. The impacts of instruction moving to being completely online posed challenges to teachers interested in developing students' ability to work on a team, providing constructive feedback to each other, and using a technical discourse. If teachers posed tasks that required peer-to-peer feedback and teamwork at all, the novel impact of doing so through zoom was an unknown.

One Nashville independent elementary school provided lesson plans each day for students to complete, with the assistance of their parents, largely asynchronously. This type of instruction was received in a variety of ways by different families with some students thriving in instruction provided in a screen-heavy and worksheet-based format. To combat the difficulties encountered by families with two working parents and children frustrated by this type of learning, I created a zoom-conference based class consisting of three second grade children. Each day Monday through Thursday for seven consecutive weeks, the children participated in a zoom session with me. At the start of each session, the students were presented with a welcome PowerPoint slide that had a mystery picture on it that linked to the engineering design challenge that would follow late in the session. We spent 30-60 minutes each session working on assigned schoolwork that was better accomplished in a group, including tasks such as spelling and math practice. Afterwards, the children were presented with a hands-on engineering design challenge that utilized materials found in their homes.

Theoretical Frameworks and Literature Review

Teamwork and Feedback Through Engineering Discourse

As a framework for the study, I refer to Vygotsky [1] who states that learning is a social act based in interpersonal communication. Teamwork is comprised of many aspects including interpersonal communication and feedback, as well as collaboration. Collaboration can be used to engage a more diverse population in engineering and to help students construct engineering identities [2]. As McLean, et al., [3] note, teamwork provides students with a variety of ways to contribute, placing a high value on contributing itself rather than on competing to come up with the best idea. This lack of a sense of competition appeals to many underrepresented populations in engineering.

Engineering discourse is a discursive complex [4] that is made up of several types of engineering discourses – scientific discourse of engineering, the management discourse of engineering, and other possible discourses such as ethics [5]. Engineering discourse includes the collection of words, visuals, and narratives through which engineers communicate [6]. The collection of words used includes the steps of the engineering design process and terms such as *criteria* and *constraints* for elementary school students. The engineering design process is an example of an engineering design routine that contributes to engineering discourse [7]. It is an explorative routine which is outcome-oriented and driven by a need to complete a particular tasks, requiring some expertise to do so [7]. Part of becoming an engineer is learning how to participate in engineering discourse and this process is complex, interactional, and non-trivial [7]. These communication processes are also reflective of professional engineering practices [8]. One desired aspect of having students participate in engineering design challenges is that they learn an age-appropriate engineering design process to support the growth of routines in engineering discourse.

McCormick, Wendell, & O'Connell [9] remind us that engineering offers the chance for students "to work toward important goals that teachers already have for children: to become better decision makers, collaborators, and problems solvers". Because students must communicate in order to work well as a team, engineering design gives the teachers to assess these skills in a way that high-stakes testing does not [10]. For all of these reasons, engineering discourse, including giving individuals or teams feedback on their design ideas and initial prototypes, is an important aspect of engineering in which elementary students should participate.

Engineering Identity

Engineers are often viewed with limited and stereotypical views [11], often as "nerdy, white, alone, and male" [12]. In order to add more and more diverse people to the field of engineering, we must expand and change the views people have of engineers to one that is more inclusive and accurate. Children must see themselves as belonging to engineering starting a young age. Elementary age children are already developing their sense of self in engineering [13] and thus elementary age students are at a crucial age for developing engineering identity [14, 13, 3].

Engineering itself must also be changed to include a variety of identities [15] and present itself as a social enterprise [16, 17]. We must engage elementary school children in engineering challenges that allow for all students to identify with engineering and to see themselves as engineers [18].

The extent to which children engage in engineering activities relies upon whether they identify with the domain of engineering [15]. Whether or not a child identifies with a domain has been shown to impact their future educational and career plans substantially [19, 20]. Thus, educators must increase the frequency of opportunities and depth of experiences for elementary age students to develop their engineering identities.

Methods

The research questions for this study were the following:

1) What are the impacts of teaching the engineering design process online via zoom conference on development of children's ability to use engineering discourse?
    a. Are students able to master the steps of the engineering design process?
    b. How do students learn to receive and implement feedback from their peers and the teacher over zoom? How is teamwork affected as compared to in-person experiences?
2) If and how do children develop their engineering identity through a series of zoom conference-based engineering design challenges?

Positionality Statement

The author of this paper is an engineering education researcher, but also a parent of one of the children in the study. My primary motivation was to offer fun, hands-on instruction that afforded time spent with the children's friends. At the same time, I was eager to offer an opportunity for these three children to explore engineering specifically as it relates to the research questions of this study.

Setting

The setting for this study was a zoom-conference based class lasting seven weeks during the initial weeks of the COVID-19 pandemic (late March to late May, 2020). The children were exclusively under the direction of the first author during the sessions, with their own parents working in other rooms in the house.

Participants

Three second grade students at an independent, co-educational elementary school took part in this experience. To maintain anonymity, the three children will be referred to as "Elizabeth", "Catherine", and "Aaron". The children are friends and have been in classes and after-school programs together in previous years. During this academic year, two of the children, Elizabeth and Aaron, were in the same class and the third in a separate class.

The children had not been previously formally exposed to the engineering design process (EDP). My child, "Aaron", is frequently exposed to conversation about engineers and the engineering design process in the home, but no specific effort had been made prior to this experience to formalize his understanding of the age-appropriate engineering design process.

This study was approved by my institutional IRB. All parents gave consent and children gave assent.

Engineering Design Process Challenges

On the Friday prior to the following week, the parents were provided with a list of challenges that would be tackled and any required materials that would be needed.

Each 90-minute session began with a photo on the welcome page as a teaser about that day's engineering design challenge. Up to the first 60 minutes were spent working on the children's assigned lessons from school, typically their mathematics, grammar, spelling and other tasks that either required collaboration, were viewed as unpleasant by the children, or worked best with someone calling aloud the task. The remaining time, a minimum of 30 minutes and a maximum of 50 minutes, were spent on engineering.

Figure 1 illustrates the engineering design process that used to scaffold the challenges. Each day the challenge was introduced, and criteria and constraints given. Occasionally, the children were asked to state the criteria and constraints after reading a book or participating in a group discussion for that purpose.

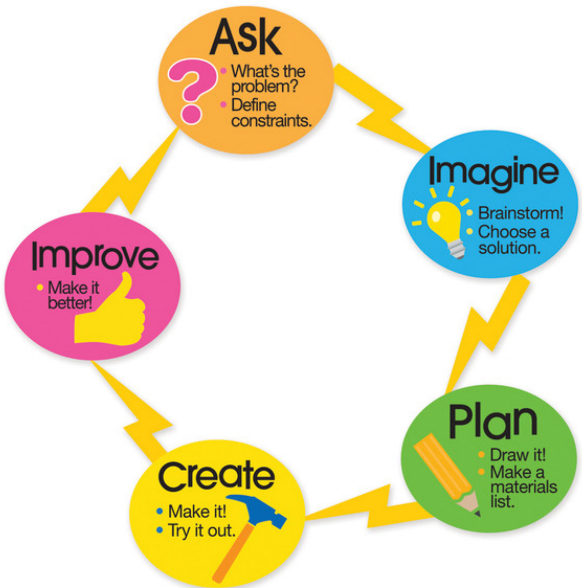

Figure 1. The Engineering Design Process used in this study to frame the challenges.

Table 1 lists all of the challenges given with some clarifying details and criteria along with the constraints mandated. Typically, the materials used were ones all children had in their house, but in two cases I provided some of the materials so that all three children had the same constraints. Specifically, I provided a hex bug for the April 15th challenge and the cups, cardstock, and small stuffed animal for the April 6th challenge.

Date	**Engineering Design Challenge**	**Constraints**
March 30	Design a parachute for a quarter	Limited material choices
March 31	Design the tallest tower possible	Use only newspaper and tape
April 1	Read Make Way for Ducklings, identify a problem that the ducks have (a safe crossing of the road) and design a solution	None
April 2	Read Make Way for Ducklings, identify a problem that the ducks have (a safe crossing of the road) and design a solution	None
April 6	Design a better view for a small stuffed animal	45 cups and 15 pieces of cardstock
April 7	Design a Lego Chair for a Bear	Legos
April 8	Design your own Soggy Dollar Bar Game	None
April 9	Design a COVID Door Opener	Works with no hands
April 13	Design a museum display base (tower) to hold a small stuffed animal that must be 12" tall	100 3"x5" notecards, 1 foot of scotch tape
April 14	Design an astronaut lander (for 2 marshmallow astronauts)	Open Styrofoam cup as lander

April 15	Design a Hexbug race	Finish the race in 50 seconds. Design the race in 20 min or less. Must go up and down a hill and be twisty during the race.
April 21	Design a removable earpiece to improve human hearing	Materials from your home or yard
April 22	Listen to the author read Beauty and the Beak. Design a new beak for the eagle. Criteria drawn from the text include desired color, functions (food and water), must have same parts as a real beak and attach in the same place.	Draw constraints from the text about size, material, etc. Materials must be sourced at home.
April 23	Finish Beauty and the Beak	
April 27	Design a straw rocket for maximum distance traveled	Must use a common base. Must use paper and scotch tape for fins.
April 28	Design a sail car that uses wind for propulsion	None
April 29	Design a puppy play space	None
April 30	Design a yarn de-tangler for knitters	None
May 7	Design a package to keep an egg safe when dropped from increasing large heights (think Humpty Dumpty!)	Limited materials
May 11	Design a prosthetic arm to carry a small cup of water	Limited materials
May 12	Design an alarm to protect a favorite stuffed animal or stash of candy	None
May 13	Design a model boat to hold the most people (pennies)	Must use aluminum foil for the boat
May 14	Design a way to make someone feel appreciated from afar	Cannot pass any physical items

Table 1. List of design challenges and their constraints.

Each day the parents received a follow-up of what took place during the session and what follow up was necessary, if any. Parents often took photos and/or videos of completed design projects and sent them to me.

Data Collection and Analysis

To answer these questions, I derived data from recordings of the online sessions and observations of student behavior and their statements, the PowerPoint slides that were used to facilitate the course, photos and videos created by parents of the students' designs, and interviews with the children. Transcriptions were created of the interviews and online sessions, providing a discourse lens through which learning processes might become visible. Qualitative data analysis began with a list of *a priori* codes drawn upon the literature that was supplemented by codes emergent codes in the data [21]. The utilization of multiple data sources allowed for a complete picture of what is taking place during the sessions and how it impacted the children's understanding and practice of the engineering design process.

Results

Overall, the engineering design challenges were very well received by the children. They looked forward to the design challenge each day, often using it as motivation to get through their required schoolwork before starting the challenge. When Elizabeth was asked what she liked about making her own beak for the eagle Beauty, she said, "probably like that it was creative" and affirmed that that applied to all of the challenges. Aaron said about the challenges in general, "I liked doing them and it made me think harder." Aaron also noted, "I really, really liked them and just thought it was something that me and my friends would like." Two of the three children, Aaron and Elizabeth, affirmed that they would like to do more engineering in their regular school and Catherine said she "probably" would. Only one challenge proved to be too difficult, the yarn de-tangler on April 30.

Figures 2-6 show sample design solutions that were created by the children.

Figure 2. Designing a parachute for a quarter – March 30 challenge.

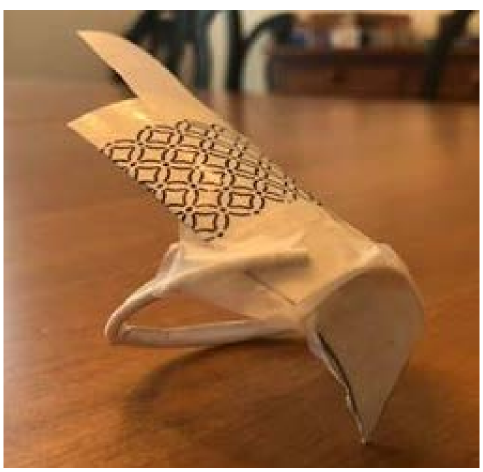

Figure 3. Designing a beak for the eagle, Beauty – April 22-23 challenge.

Figure 4. Designing a better view for a stuffed animal – April 6 challenge.

Figure 5. Design a boat to hold the most people (pennies) – May 13 challenge.

Figure 6. Designing a straw rocket – April 27 challenge.

Knowledge and Use of the EDP

The children became very facile with the EDP and its steps. In the final interviews conducted with each child, all three could name the steps of the process as detailed in Figure 1 above. Aaron and Elizabeth specifically named "feedback" as part of the testing process.

Two of the three students could accurately define the terms *criteria* and *constraints*, while the third child said that she did not remember those words. One child said that *criteria* was defined as "what you're supposed to do" and that *constraints* were "what you don't have versus what you do have". Their understanding of constraints was primarily limited to materials, and occasionally time. This child also noted that "the kids can make the constraints" in addition to being given constraints.

Elizabeth was the most articulate about how she used evidence to make design decisions in the final interview. In one of the challenges requiring height and stability, she commented, "It kind of makes it a little more stable … because if you don't do it there it gets a little more wobbly."

Teamwork and Feedback Through Engineering Discourse

Though I originally hoped to have the children work as a team to create one design solution for a challenge, we never moved from independent solutions to a true team solution. The children truly enjoyed imagining their own solutions and utilizing the materials that they had on hand – which often didn't match what other students had on hand. Given the material and time constraints, the children were challenged to slow down and share their own solutions and to receive feedback on those solutions so that they could improve their designs. To this end, I focused on collaboration and teamwork through feedback only.

Occasionally, Aaron struggled to understand the meaning of what Catherine tried to say about her designs and that resulted in frustration for both children. At times all three children struggled to give and especially to receive feedback from their peers, particularly when it involved criticism of the design.

In the early project of designing a solution for the ducks on April 2, the children were able to give feedback when specifically requested to do so.

Speaker	Speech	Gesture
Author	Can you tell me the part about the part the ducks go on?	
Elizabeth	The ducks avoid the bridge because they don't want to be roadkill. So they go into this thingy. And then I can't get it to stand up like this so I'm just leaving it like that.	Indicates her design
Author	That sounds like a great first design. Catherine or Aaron, do you have any feedback for Elizabeth about how she could improve her design or just any questions about why she did what she did?	

Aaron	I think the bridge doesn't need to be straight down and so thin because the ducks might fall off and there needs to be little walls on the sides.	
Elizabeth	Yeah, I can't do that but … or else it will weigh it down so much. And I can't stand up this end.	
Author	Could you put more support under it?	
Elizabeth	Yeah, I tried to use this [shows a craft stick]. I tried to use that for support but it ended up being part of the bridge.	Shows a craft stick here:

Later in this session

Speaker	**Speech**	**Gesture**
Author	Suggestions for how she [Catherine] could make even better than it already is?	
Elizabeth	I think you might want to use popsicle sticks instead of these thingies because it just takes up way more space. And also if cars, if they were to actually drive they would just crash into each other.	
Aaron	Yeah.	
Catherine	Cars actually can't um, wouldn't be able to crash 'cause this can come off the tape and then space it out.	
Elizabeth	I don't know what that means. But Catherine, because there's two rows of them. There's only supposed to be one row.	
Catherine	Elizabeth, but there's whole road but then there's these things on the sidewalks.	Scowls.
Elizabeth	I know Catherine, but if the cars were actually going to go, they would crash into each other.	

By April 23rd and the Beauty and the Beak challenge, the children have made strides in giving and receiving feedback.

Speaker	Speech	Gesture
Author	I want us to each really listen to each other and watch. I'll spotlight you when it's your turn. I want you to offer constructive feedback. So you might say, "oh, this is great, but I think you can make it even better by doing XYZ". I want you to hear that and think about, really analyze it and see if you think it will be better so that we can make some improvements. Aaron's going to go first here.	
Author	Do you see how it attaches there?	
Elizabeth	I want to see it demonstrated.	
Author	Ok do you want to come peck on me? Ok. What feedback can you offer Aaron?	Aaron uses designed beak to peck on author's face.
Elizabeth	Maybe you can make it a little harder material. I know I will have to say that for me too. It's just the cup I was going to use was too big.	
Author	Ok, so Elizabeth offers you that you could use a harder material. Catherine, do you have something to offer Aaron?	
Catherine	Maybe he could have made it a bit bigger?	
Aaron	That would have been very hard, and Elizabeth, this is the strongest I had other than cardboard which would be very hard.	
Author	oh, we'll have to see. So those are two good pieces of advice.	
Author	Aaron, set yours down and Catherine let's see yours.	

Author	Oh! She's got a tongue in there!	
Author	Aaron, what helpful feedback do you have for her?	
Aaron	Make it stronger, like, stronger on you. See how I taped it to my nose and had this little ring so I could bite on?	
Catherine	Aaron -	
Aaron	I wouldn't do that on yours…	
Catherine	I might do that but it doesn't matter the way it connects. It just matters that it stays on.	
Author	You're right that the method doesn't matter but that it stays on. Well said. Elizabeth, what helpful feedback do you have?	
Elizabeth	Make it a little pointy.	
Author	So, a little stronger in its attachment and a little pointier.	
Aaron	What if it was trying to eat? It tears it off. What if it's trying to fight? And if it does that, the beak will just fly off. So that's why I added the little ring.	Aaron shakes his head back and forth violently
Author	So that was good feedback so far. Now let's give our attention to Elizabeth.	
Catherine	Wait can I say something to Aaron real quick that is about his feedback to me? I know that I would put a pointy part but I chose my own part. I chose one part in the story that we read yesterday and decided to do that when that happened.	[She is implying that she built the part that remained on the bird]
Author	Ok, Elizabeth…	
Aaron	There's one thing I can already say. It needs to be pointier.	

Author	Ok, Andrew suggests that it could be pointier.	
Elizabeth	I know. It was just hard to make it pointy with this lid on.	
Elizabeth	I was trying to make it all yellow.	
Author	I see the pointier part when you take that part off.	
Catherine	It doesn't really matter the way if it's pointy or not. It just matters that it can do certain things or it looks like a beak.	
Aaron	There's one thing I want to say to your feedback, Catherine. How will it eat then?	
Elizabeth	Yeah.	

The children were able to derive ideas from the work of others as well as from their parents outside of class time. Catherine indicated in the final interview that overall she got feedback more from Aaron more than from Elizabeth or her parents. Some doubts about her own abilities and design also emerged in discussing the May 13th challenge where children designed boats out of aluminum foil.

Speaker	**Speech**	**Gesture**
Author	Where did you get your ideas for how to improve that boat?	
Catherine	um from … uh from um Elizabeth and Aaron. Because um Elizabeth's boat was like really tall which I'm pretty sure I cannot make that.	

Aaron received feedback from his parent, this author, at times. He commented that he learned about the science behind why things float from me and that improved his boat design. He explained, "I improved it by making it different and then making it different in a way that it had a flat bottom and then making a few more and seeing making higher walls". When asked about the Hexbug maze design, he reflected the following specific memory.

Speaker	Speech	Gesture
Author	What kind of suggestions did you get for improvement from your fellow classmates or your teacher on the hex bug?	
Aaron	um making it some curves and making like no gaps so that it could get stuck in	
Aaron	Um probably the hex bug maze. Making it go up ramps but it can go down ramps	
Author	Okay	
Aaron	It could go down ramps but it can't go upstairs, up ramps.	
Author	What kind of suggestions did you get for improvement from your fellow classmates or your teacher on the hex bug?	
Aaron	Making it some curves and making like no gaps so that it could get stuck in	
Author	Did you like getting this feedback?	
Aaron	It made me a little bit frustrated but not a lot because i might get this whole thing like this and then I did this.	

Elizabeth noted that "you've got to hear other people's ideas too. So you can kind of add on to your thing." On multiple occasions she recalled specific feedback from her parents that positively affected her designs and how far she took them outside of class time. For one of the cup stacking challenges, she remarked:

Speaker	Speech	Gesture
Elizabeth	I got the idea of the way that the cups are stacked by Cate. But then I kind of added my own little thing.	
Elizabeth	Definitely that cup stacking one 'cause I really did kind of, well, yeah, because every time I put two layers of that cup, I didn't, at first, I didn't put paper in between it. So then it just just fell down after I did three layers. But then I tried to put paper in between that every four layers, like there would be two layers of cups stacked on each other. Then there would be two layers of papers and you keep going. And then after my mom said it was too tall. After the zoom, I decided to use the rest of the cups that I had in the sack that you gave us and I	

	just kept on building. I didn't have any more cups. I couldn't use my actual cups because they would be too heavy.	

In the final interview, I also specifically asked the children about giving feedback to the other children.

Speaker	Speech	Gesture
Author	You can think about that project in particular, or other ones in general: Did you like getting feedback on things you could consider changing about your design?	
Elizabeth	Um, yeah, kind of. I mean, it depends on what type of feedback they're giving.	
Author	Tell me about that.	
Elizabeth	But it depends on if they're correcting you or just like giving you ideas.	
Author	It doesn't make a difference, doesn't it? kind of an attitude?	
Elizabeth		Nods in agreement

Asking the same questions of Andrew:

Speaker	Speech	Gesture
Author	Do you think it would have made a difference either on this hex bug project or I don't know beauty and the beak or any of the other ones if you had been together in a one room rather than over zoom?	
Aaron	I thought we could interact and do it together almost but still and get more feedback and so that we could see it better.	
Author	In our zoom session how did we work as a team?	
Aaron	By getting feedback from each other	
Author	Do you feel like people gave and received feedback well? That's kind of two questions you feel like people did a good job of giving each other some feedback?	
Aaron	Yeah but there's one thing that I would like different about that is that it was like it was so that everyone could actually understand what they were saying because sometimes i can't understand what Catherine or Elizabeth said.	

Author	You couldn't understand the words or you just couldn't understand what they were trying to say.	
Aaron	Yeah, what they were trying to say.	

Engineering Identity

Towards the end of the interviews at the end of the seven weeks, I asked each of the three children, "[Name], are you an engineer?". Aaron replied with an unequivocal "yes". Elizabeth responded "I guess 'cause we've been engineers or 'cause we've been doing the engineering design challenge all through quarantine. So I guess so." Catherine was a bit less direct in her response, though eventually responding affirmatively.

Speaker	**Speech**	**Gesture**
Author	So [Catherine] are you an engineer?	
Catherine	Mmmmm…. Give me one second…. By the way I drew something from drawing something for to carry my baby dolls around. Okay basically it's like pull my baby dolls around.	Shows drawing with a big "yes" on it
Author	Yes	Laughter
Author	I was hoping you would say yes because I think you're an engineer too. Why did you say yes?	
Catherine	Because uh most of the challenges I could handle and like finish and improve	

Discussion and Implications

RQ1) What are the impacts of teaching the engineering design process online via zoom conference on development of children's ability to use engineering discourse?

a. Are students able to master the steps of the engineering design process?
b. How do students learn to receive and implement feedback from their peers and the teacher over zoom? How is teamwork affected as compared to in-person experiences?

The children enjoyed engineering and looked forward to the engineering design challenges each day. The children become better problem-solvers through the seven weeks as they exhibited more patience and persistence with the design solutions. As evidenced in the final interviews, they became facile with the engineering design process and, in two of three cases, terms such as *criteria* and *constraints*. They began to seek out feedback on their design solutions, typically from the author and sometimes from their parents. They also became familiar with the explorative routine of the engineering design process, not really needing prompting to begin testing or to improve their designs.

Due to the COVID quarantine and different materials found in each house, it proved too challenging to create projects that would allow for true teamwork in creating a single solution to the design challenges. Thus, this study does not attempt to address the full gamut of teamwork. This study does look at collaboration and particularly engineering discourse through feedback. The students do not seem to be competitive with each other to create the "best" design on each design challenge. They do, however, struggle to give and receive feedback at times. Frustrations arose when Catherine struggled to articulate her designs and thought processes. These difficulties were likely amplified by the setting of zoom where it was more difficult, but not impossible, to show a design solution in addition to describing the design solution. It was difficult for a child responding to another child's design not be able to touch it or gesture towards it. It may have been more difficult to resolve the increased communication frustration over time between Aaron and Catherine because of the zoom conferenced based setting and no way to spend time together in person playing or doing other things. It is difficult to separate the effects of the zoom conferenced based setting with the effects of the COVID-19 quarantine.

> RQ2) If and how do children develop their engineering identify through a zoom conference-based engineering design challenges?

An assumption can be made that Catherine and Elizabeth started with a minimal or non-existent engineering identity because they had not participated in engineering activities at school and none of their parents is an engineer. Aaron likely started with a slightly more established engineering identity, having had the chance to complete some engineering design challenges at home informally and having two parents that studied engineering. After completing 21 unique engineering design challenges over the course of seven weeks in which all three children engaged deeply, the children had been exposed to the engineering design process 21 times as well as to some specific fields within engineering. All three children, two with more decisiveness in their responses, now claim to view themselves as engineers. One child further clarified her response by noting that she had been doing engineering work for weeks and that seemed to imply that she must be an engineer. The online, zoom-conference based setting of these experience appears not to have hindered the development of an engineering identity for these three children.

An additional benefit of this course set-up is that the parents were also exposed to engineering and its benefits. The parents received weekly emails about what the design challenges would be for the next week and what materials needed to be gathered. Each day they received a follow-up of what took place during the session and what follow up was necessary, if any. Parents often took photos and/or videos of completed design projects and sent them to me. This parental knowledge of and exposure to engineering is also important as parents play a role in supporting students, especially girls, in choosing future education and career pathways.

Limitations

A limitation to this study is that the author is the parent of one student participant and knows the other two children. The children may have felt compelled to give answers that they thought the author wanted to hear during the interviews and the sessions themselves.

Because this was a one-time limited experience of three children during extraordinary times, the results may not be broadly applicable. The research questions should be further addressed with studies on a larger number of children and in different settings.

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