AC 2009-117: SIGNIFICANT CASES OF ELEMENTARY STUDENTS’ DEVELOPMENT OF ENGINEERING PERCEPTIONS

Irene Mena, Purdue University
Irene Mena is a doctoral student in the School of Engineering Education at Purdue University. Her M.S. and B.S. are both in Industrial Engineering. Her research interests include K-12 engineering education, first-year engineering, and graduate student professional development.

Brenda Capobianco, Purdue University
Dr. Brenda Capobianco is an Associate Professor in the Departments of Curriculum and Instruction and Engineering Education, as well as Affiliated Faculty in Women's Studies at Purdue University.

Heidi Diefes-Dux, Purdue University
Dr. Heidi Diefes-Dux is an Associate Professor in the School of Engineering Education at Purdue University. She received her B.S. and M.S. in Food Science from Cornell University and her Ph.D. in Food Process Engineering from the Department of Agricultural and Biological Engineering at Purdue University. Since 1999, she has been a faculty member within the First-Year Engineering Program at Purdue, the gateway for all first-year students entering the College of Engineering. She coordinated (2000-2006) and continues to teach in the required first-year engineering problem solving and computer tools course, which engages students in open-ended problem solving and design. Her research focuses on the development, implementation, and assessment of model-eliciting activities with realistic engineering contexts. She is currently the Director of Teacher Professional Development for the Institute for P-12 Engineering Research and Learning (INSPIRE).
Elementary engineering, or the inclusion of engineering ideas and concepts into the elementary school curriculum, is an area that has been recently developing. Because it is still an emergent area, not much is known about how students develop engineering understanding. The purpose of this study was to examine grades 3-5 students’ perceptions of engineering, the engineering design process, and the work of engineers as a result of engaging in a series of standards-based engineering learning activities. Emphasis was placed on identifying three cases of significance, one from each grade level, whereby the students exhibited significant growth in understanding of what engineering entails, what engineers do, and how the engineering design process works. Using situated learning as a theoretical lens, researchers in this study explored how students constructed and re-constructed their understandings before and after the learning experiences. Data were collected in the form of pre- and post-administration of the Draw-an-Engineer Task (DAET), the Engineering Identity Development Scale (EIDS), knowledge assessments, and semi-structured interviews. Data were analyzed using content analysis and grounded theory. Results from this study indicated that the three students reported more accurate and informed perceptions of engineers, specific examples of professional engineers, and improved understanding and application of the engineering design process, as a result of participating in the engineering learning activities. Implications for this study reinforce the notion that multiple data sources are necessary for accurately assessing what students do and do not know about engineering. Furthermore, this study sheds light on the need for the design and implementation of learning activities that will challenge and transform students’ misconceptions about engineering.
In this study, the researchers focused on three unique cases, classified as “cases of significance”. These cases were defined as individual cases of students from grades 3, 4, and 5, respectively, who demonstrated growth over time as a result of engaging in discrete, standards-based, authentic engineering learning activities. Growth was assessed by gains across multiple data sources, including students’ drawings, interviews, and performance on assessments.

Previous studies indicate that elementary students are unfamiliar with the work of engineers. Oware, Capobianco, and Diefes-Dux\(^1\) found that students associated engineering with fixing, building, and working on things, and when asked to draw engineers, they were many times portrayed as physical laborers. Also, several students believed that in order to perform their work, engineers needed items such as blueprints, computers, and safety gear. Similarly, Cunningham, Lachapelle, and Lindgren-Streicher\(^2\) found that students generally associated fixing, vehicles, and building with engineering. As a result, it has been deemed necessary to design curriculum to address students’ misconceptions and help them gain a more accurate understanding of engineering. This can be a difficult task, as there is not always available space in the curriculum for engineering, and teachers rarely feel comfortable teaching engineering\(^3\).

This study looks at the effects of authentic learning activities on grade 3, 4, and 5 students’ understanding of engineering and the work of engineers. The learning activities were designed using the *Engineering is Elementary* curriculum\(^3\) as a model. *Engineering is Elementary* ([www.mos.org/eie](http://www.mos.org/eie)) is an example of how engineering can be incorporated into the elementary classroom. Hester and Cunningham\(^3\) write that its goals are to: “increase children’s technological literacy”, “increase elementary educators’ abilities to teach engineering and technology to their students”, and “modify systems of education to include engineering at the elementary level”. The activities are designed to include a science topic, an engineering discipline, and a design challenge, all set in the context of stories and characters from different countries. Throughout the activities, students learn about and use the engineering design process which consists of the following steps: ask, imagine, plan, create, and improve\(^3\).

**Research Question**

The research question for this study is: In what ways does the integration of elementary engineering learning activities impact grade 3, 4, and 5 students’ perceptions of engineering, the engineering design process, and the work of engineers?

**Theoretical Framework**

This study draws upon the construct of situated learning. According to Lave and Wenger\(^4\), situated learning suggests that learning can be situated in social and cultural settings, and that if a learning activity falls beyond the cultural understanding of the learner then learning is likely, at best, to be less successful than if it had been situated in a more familiar setting. A central idea to situated learning is that learners must be exposed to, and engage in, authentic learning tasks\(^5\). Authentic tasks are tasks which students can relate to their own experience inside and outside of school; tasks which an experienced practitioner would undertake\(^4,6\) – in this case, a professional engineer. In this study, the teachers developed and implemented various engineering learning
tasks grounded in the design process and the work of professional engineers (i.e. mechanical, environmental, and chemical engineers) while simultaneously merging these ideas, concepts, and skills with children’s use of everyday technology (e.g. simple machines at home and in school), children’s ideas of current science issues and topics (e.g. water conservation and purification), and children’s abilities to work collaboratively in a social setting indicative of the engineer’s workplace. When learning is composed of authentic tasks, there is a greater probability of engagement with the task and also with the information and ideas involved with the tasks. Authentic tasks are more likely to hold the attention and interest of students and lead to deeper levels of engagement than other similar but more traditional classroom or less authentic tasks. This links closely with the ideas of sociocultural learning theorists, such as Bruner and Brown, Collins, & Duguid. In this study, we examined students’ engagement in such tasks and furthermore, explored how their engagement in authentic engineering learning activities informed their perceptions of engineering, the design process, and the work of engineers. What follows is a brief overview of several engineering learning tasks grade 3, 4, and 5 students engaged in:

*Constructing towers* – Using the provided materials and considering the established constraints, students worked as engineers to design and build a tower out of index cards that would support a stuffed animal.

*Designing sails* – As engineers, students predicted which common household materials worked best to catch the wind when used as a sail; discussed properties of materials and how those properties affect how the sails catch the wind; observed and described how different sail materials and shapes catch the wind; and tested different sail designs.

*Testing water purifier* – Students modeled the work of environmental engineers by addressing the problem of purifying contaminated water. Students worked in teams to design, construct, and test a prototype of a water purifier.

Students worked in teams of three to four students during each task. Each task served as an authentic learning task that required student teams to make decisions to achieve predetermined goals while complying with constraints, thus imitating the work of an engineer.

**Context of the Study**

The study took place in an urban elementary school setting (grades K-5) that houses 369 students and 26 teachers. The demographics included: 68% White, non-Hispanic, 26% Hispanic, 2% Black, non-Hispanic, and 1% Asian/Pacific Islander. Of these students, 43% have free lunch, 12% reduced-price lunch, and 55% low-cost lunch.

Within the school, three teachers (one from grade 3, 4, 5, respectively) were purposefully selected to participate in this study. The three teachers attended a summer workshop on implementing elementary engineering learning activities in their classrooms. The activities stressed knowledge of engineering and the work of engineers, the engineering design process, and science content knowledge specific to each individual activity. The teachers then returned to their classrooms, developed and implemented a three to five week engineering design unit based
on their professional summer experiences. The researchers in this study collaborated with the teachers on the design, implementation, and assessment of each lesson and overall units by consulting with them weekly, making classroom observations, and, in some cases, co-teaching. Grade 3 and 4 teachers focused on the concepts and skills associated with simple machines as well as the work of mechanical engineers. The Grade 5 teacher focused on a water unit, how to filter contaminated water, and the work of an environmental engineer.

**Student Participants**

A total of 85 students (41 males; 44 females) from grades 3, 4, and 5 participated in the larger study. There was one control (no engineering activities implemented) and one treatment or experimental class (engineering activities implemented) for each grade level, for a total of six classes.

For this study, three student participants from the experimental classrooms were purposefully selected from the sample based on the following criteria: 1) a student representative from each grade (grades 3, 4, and 5); 2) how clearly and freely the students conveyed their responses for each assessment; and 3) evidence of growth or change from pre- to post-administration in two or more of the assessments.

The researchers in the study included one faculty member in the Departments of Curriculum and Instruction and Engineering Education, one faculty member in Engineering Education, and one doctoral student in Engineering Education. The researchers participated in the data collection and data analysis.

**Research Methodology**

Mixed methods were used in this study, with an emphasis on qualitative methods. The qualitative methods included pre- and post-administration of the Draw an Engineer Task (DAET), and semi-structured interviews. Each student participant was asked to complete the DAET, where they were instructed to draw an engineer doing engineering work and then participate in a 15-20 minute follow-up interview. In the interview, students were asked to describe their drawing, discuss what an engineer is, and if they have participated in engineering activities. The post interview questions included all of the pre interview questions as well as additional questions. These follow-up questions asked students to compare and contrast their first and second drawing, reflect on class activities, and share anything new they learned.

The quantitative methods included pre- and post-administration of the Engineering Instructional Knowledge Tests and the Engineering Identity Development Scale (EIDS). The Knowledge Test consisted of 10 to 15 multiple-choice items that were adapted from assessments items from the Engineering is Elementary modules, Trends in International Science and Mathematics Study (TIMMS, [http://nces.ed.gov/timss/](http://nces.ed.gov/timss/)) and state standardized exams. Each test focused on three domains of knowledge: 1) knowledge of specific science and mathematics content; 2) knowledge of the engineering design process; and 3) knowledge of the work of different types of engineers. Science and mathematics concepts and related content were determined by the teachers; in grades 3 and 4, this was simple machines and in grade 5, water. An example of a content
question included the following: A simple machine: A) makes energy; B) uses energy to complete a task; C) does not involve energy; D) does not need energy to do work. An example of a design question was: Mary and Tom are working on the design of a soccer ball that will spin when it is kicked. They are making a list of materials they will need. Which step of the engineering design process are they working on? A) ask; B) imagine; C) plan; or D) create. An example of a question related to the work of engineers included the following: Which of the following involves the work of an industrial engineer? A) Designing machines to work more efficiently; B) Assembling materials; C) Inspecting the quality of materials; D) All of the above

The final assessment included a pilot implementation of the Engineering Identity Development Scale (EIDS). According to Lave and Wenger, the construct of identity formation is interwoven with the processes of learning. Hence, the EIDS was designed to assess the intersection between student learning and identity formation. In this study, the EIDS was piloted with the understanding that subsequent administrations of the scale would be warranted. The EIDS consists of four subscales, each targeting a different dimension of identity: academic identity, school identity, occupational identity, and engineering aspirations. Students used a three-point Likert scale (1 = disagree; 2 = not sure; 3 = agree). Examples of these statements include: I do my schoolwork as well as my classmates (academic identity); I like being a student at my school (school identity); Engineers work in teams (occupational identity); and When I grow up I want to be an engineer (engineering aspirations).

Analysis

As previously explained, three student participants from the experimental classrooms were purposefully selected. The data analysis process began by analyzing each individual case. Each student’s DAET and interview transcripts were first reviewed. Open coding was done on the transcripts to see what themes emerged from the data. Throughout this process, “like-minded” pieces were put together in “data clumps” and assigned a code, as suggested by Glesne. After refining and verifying these codes, final codes were obtained and analyzed for frequency and strength of the statements. This strength testing led to the development of assertions.

Each student’s pre and post interview and DAET were compared to see how the students’ perceptions of engineering, the engineering design process, and the work of engineers changed after the elementary engineering activities were implemented.

The findings from each student’s interview and DAET were then compared to that student’s Knowledge Test and EIDS results, providing within-case triangulation. The Knowledge Tests were scored based on the number of correct responses, overall and in each of the three knowledge areas. For the EIDS, means were calculated for each of the subscales and compared between the pre and post tests. The pre- and post-test results were compared to note the changes in overall scores as well as in the different dimensions of identity.

After each case was individually analyzed, the next step was to compare the findings from the three cases in order to determine the overall effects of the elementary engineering learning activities.
Results

This paper highlights three cases of significance, one from each grade, found in the study. The findings are presented based on each individual case of significance.

Ron

Ron is a male student in grade 3. For his pre DAET, he drew a man with a wrench in his hand, fixing a car (Figure 1):

“...this is an engineer, which I think an engineer is a person that fixes cars and he’s fixing his racecar in the pits.”

Figure 1: Ron’s pre DAET

The main finding in Ron’s pre interview is that while he recognizes that he does not have enough knowledge about engineers, he associates them with fixing cars. When he was asked why he drew a man fixing a racecar, his answer was:

“’Cause I really don’t know what an engineer is so I just put him in here down fixing a car.”

When asked if he would like to be an engineer when he grew up, his response was:

“If I knew what engineers really were, besides persons fixing a car, maybe.”

Ron’s Knowledge Test and EIDS scores can be found in Table 1 and Table 2, respectively. On the pre Knowledge Test, Ron correctly answered 50% of content-related questions, 100% of questions related to the design process, and 0% of questions related to the work of engineers, for an overall mean score of 0.50. Ron’s EIDS results (Table 2) indicated a high score for school identity and a neutral score (or “not sure”) for academic identity, occupational identity, and career aspirations.
Table 1. Student performance on pre/post Engineering Knowledge Tests (Percentage of correct responses)

<table>
<thead>
<tr>
<th>Knowledge Area</th>
<th>Ron Pre</th>
<th>Ron Post</th>
<th>Daisy Pre</th>
<th>Daisy Post</th>
<th>Paula Pre</th>
<th>Paula Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Design Process</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>Work of Engineers</td>
<td>0%</td>
<td>50%</td>
<td>70%</td>
<td>100%</td>
<td>25%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2. Student responses to pre/post EIDS (Mean)

<table>
<thead>
<tr>
<th>EIDS Dimension</th>
<th>Ron Pre</th>
<th>Ron Post</th>
<th>Daisy Pre</th>
<th>Daisy Post</th>
<th>Paula Pre</th>
<th>Paula Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Identity</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>School Identity</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Occupational Identity</td>
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<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Engineering Aspirations</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Hence, Ron’s interview responses, pre Knowledge Test and pre EIDS scores, clearly indicated a lack of understanding and uncertainty about the work engineers do and his own career aspirations.

For his post DAET, Ron drew a male environmental engineer saving fish from an ocean that was filled with oil (Figure 2).

Figure 2: Ron’s post DAET

While in his first interview Ron thought engineers fixed cars, in his second interview he had different ways of describing engineers:
“[An engineer is someone who] makes stuff better.”

“…an engineer isn’t just someone fixing a car, it’s all kinds of different people doing all kinds of different stuff and the reason why I said someone fixing a car is because that was before I knew, didn’t know anything about engineering so that’s why I said something, somebody fixing a car ‘cause pretty much that’s what came to mind…and that’s stuff before I knew anything about engineers but now I know lots of stuff, so it’s different, really really different because not just engineers fix cars, engineers do all kinds of different stuff.”

The main findings in Ron’s post interview were: he was able to describe different types of engineers and the type of work they did, he associated engineering with helping people and the environment (engineers “make your life better” and “keep the earth together”), he was able to explain the steps of the engineering design process, and he was aware that he did not know much about engineers before but that he now had a better understanding of the work they did.

On the post Knowledge Test, Ron correctly answered 50% of the content-related questions, 50% of the questions related to the design process, and 50% of the questions related to the work of engineers, for an overall mean score of 0.50 (Table 1). Results from the post EIDS revealed high academic and school identities, knowledge of the work of engineers, and uncertain engineering aspirations. Compared to his pre EIDS results, Ron showed increased knowledge of the work of engineers and a higher academic identity. According to the EIDS, his school identity and engineering aspirations remained the same.

The gains in Ron’s knowledge of the work of engineers, revealed in the post Knowledge Test and post EIDS, also appeared in the interview:

“Well the civil engineer like plans stuff and then gives it to the mechanical to build it and then the electrical does the, all the wiring and the chemical makes bottles and makes like…medicine, and the environmental saves the world and makes sure that there’s no stuff that can harm the earth.”

Although Ron did not indicate a high score with engineering aspirations on the post EIDS, he did say that he would like to be an environmental engineer when he grew up:

“Because I like environmental the most and that I wanna try stopping global warming because the, because all the animals up in the Arctic, in the Arctic…are dying because of global warming because we’re not taking care of the earth enough to stop that, it’s melting and killing animals, so I wanna just try to stop doing that.”

Ron demonstrated gains in knowledge of the engineering design process. This was further elaborated in his second interview.

“…well the asking is you ask how is it gonna look or how are we gonna put it together and what are we gonna use, and then the imagine part is when you just think of it and put
your ideas on paper, I think that’s more of the planning part…and then you, you just
think of it and you move on to the planning, that’s when you put your ideas down on
paper and you move on to the designing…designing, designing process, well the building
or whatever…[Interviewer asks: Creating?], creating, yeah, and then that’s when you
build it and then if it doesn’t work then you step on, you go on to the improve…and then
you make it better and keep on doing it over and over, just keep on doing it until it’s just
right.”

Daisy

Daisy is a female student in Grade 4. Her pre DAET (Figure 3) included:

“… a car, the engineer burned.”

Figure 3: Daisy’s pre DAET

One of the main findings in Daisy’s interview was that she associated engineers with the term
“engine.” Throughout the interview, she referred to the car’s engine as the engineer. Another
finding was that, when prompted, she associated engineers with “fixing cars” and with being
familiar with “math, science, and mechanics.”

On the pre Knowledge Test, Daisy correctly answered 50% of the content-related questions,
100% of the questions related to the engineering design process, and 50% of the questions
related to the work of engineers, for an overall mean score of 0.70. Her pre EIDS results showed
a high academic and school identity, lack of knowledge about the work of engineers, and
uncertain engineering aspirations.

For her post DAET, Daisy drew a female mechanical engineer designing a machine that would
put together clothes (Figure 4).
She described engineers as follows:

“A **person that does something to help the world.**”

“[An engineer is someone who] **does something to help make work easier...**”

The main findings in Daisy’s post interview were that she associated engineers with helping (an engineer is someone that “**does something to help the world**”), and that she indicated a new understanding of the work of different types of engineers. She also recognized that before, she did not know what engineers did, but she now had a more accurate understanding. Furthermore, she was familiar with the design process, stating that it represents “**what engineers do**” and further named her most and least favorite steps: “**imagine**” was her most favorite, while “**create**” and “**plan**” were her least favorite.

Daisy correctly answered 100% of the questions in the post Knowledge Test for a mean score of 1.00. The post EIDS revealed an increase in knowledge of the work of engineers. This was reinforced in her second interview:

“A **chemical engineer makes products like shampoo, soap and other stuff so we can do, clean things.**”

“A **civil engineer is a person who does bridges, roads, and buildings....Make them be stronger and to be safe to be inside there.**”

“A **mechanical engineer helps people do work easier, an environmental engineer helps the earth by cleaning water, picking trash up and other stuff.**”

“[An **industrial engineer**] works usually on factories so the products that other engineers do go out.”
Paula

Paula is a female student in grade 5. In her pre DAET, Paula drew a male engineer drawing a house or building that was later to be built (Figure 5).

![Figure 5: Paula’s pre DAET](image)

She believes drawing is an important skill for an engineer, as an engineer is someone who:

“...makes things to become real things. Most of the time draws it and sketches it out to become real things.”

Designing is a word that Paula frequently used to describe engineers and the work of engineers, saying that she learned about this:

“...off the commercials about Ivy Tech and mostly about people designing things on commercials.”

The main findings in Paula’s interview were that she associated engineering with designing and drawing as well as with making and building.

On the pre Knowledge Test, Paula correctly answered 100% of content-related questions, 50% of questions related to the engineering design process, and 25% of questions related to the work of engineers, for a mean score of 0.60. Like Ron, Paula indicated a high academic identity and neutral scores on the remaining three subscales.

In the post DAET, Paula drew a female environmental engineer working with someone to design a machine that will keep plants safe (Figure 6). The engineer is:

“...working on a paper that is designing a way to keep plants safe, like from desert animals or any kind of thing that can hurt ‘em.”
As in the first interview, Paula mentioned that design was an important part of engineering, and defined an engineer as someone who:

“Designs things for other people or helps make things easier for us.”

“Engineers don’t make things, they design them and then give the people like, I’m not sure if they give ‘em to factories, but they give ‘em to people to make ‘em become real things, they don’t make them, they design them so they can give ‘em to a person that just makes things.”

“[Engineers design things that] make our life better or easier.”

The main findings in Paula’s interview were that she associated engineers with helping people and the environment, and with designing instead of building and making. She also was aware that there were different types of engineers and provided some examples.

Paula’s overall mean score on the post Knowledge Test was 1.0. The post EIDS scores indicated gains in academic and school identities, and knowledge of the work of engineers which also appeared in her interview responses:

“An environmental engineer does things to help the outdoors, like the environment, and the thing it mainly works to keep clean or help is water, soil, and the air.”

“[Mechanical engineers]…probably design a better way, like, they had…on the news this morning that was talking about engineers and how they were, they needed engineers to find better technology to get the bumpers and the parts of their car stronger so they can, so they don’t crash and it damages that much, and the damage is less.”
Discussion

The results from this study lead to the following assertions regarding students’ perceptions and knowledge after the implementation of the elementary engineering learning activities:

1. The students provided accurate and discrete examples of different types of engineers.
2. The students demonstrated improved understanding of the engineering design process.
3. The students associated engineers with helping people and the environment.
4. The students expressed that they previously did not know what engineers did, but now do recognize the type of work they do.

These effects of exposure to engineering in the classroom are similar to existing studies. Thompson and Lyons examined the effect of having STEM graduate students act as resources and co-teach in elementary schools. Results demonstrated changes between pre and post DAET, with more “mental aspects of engineering” found in the post DAET. Students also demonstrated understanding of different fields of engineering and began to see engineering as involving processes.

Similarly, in a study looking at gifted students’ perceptions of engineering before and after their participation in an engineering outreach course, Oware, Capobianco, and Diefe-Duex found that students’ perceptions did change after being exposed to engineering. Students demonstrated more accurate perceptions of engineering, as well as knowledge of different fields of engineering and problem solving in engineering.

In their post interviews, the students associated engineers with helping others and the environment. This shift from fixing cars to helping the world is a positive change in the image of engineers, and in the type of students engineering will be attracting. For example, more girls might be interested in an engineering degree in the future if they realize that engineering is not restricted to fixing cars but may actually give them the opportunity to do a variety of things, including helping in different ways. In fact, one of the reasons students are motivated to become engineers is the belief that engineering is “socially beneficial”.

The students in this study started with their own original ideas about engineering; there were few commonalities in perceptions. Ron thought engineers fixed cars, Daisy thought an engineer was actually an engine, and Paula thought engineers designed, drew, and made/built things. After the engagement, the students had more informed, accurate perceptions. Thus, the assertions made in this study are supported by the construct that learning takes place in a context. In this study, student learning was situated within a context that teachers provided through authentic engineering learning activities. As the data indicated, students developed new skills and gained new knowledge and understanding of engineering and, in some cases, even mastered and transferred their learning to new situations. This work reinforces the link between the idea of learning being situated and the need for authentic learning tasks.

Conclusions

The purpose of this study was to explore children’s perceptions of engineering, the work of engineers, and the engineering design process and how these change after the implementation of
elementary engineering activities. This study focused specifically on three cases of significance. The results indicated that students gained new knowledge about the work of engineers and the engineering design process. In addition, students demonstrated gains in several identity dimensions, further indicating a positive impact on how students begin to think about their personal interests in and identification with engineering.

This study is limited by two major factors. First, the study examines responses from a limited number of participants. Once again, this study was case-based; however, attention could be given to increasing the number of participants. Second, this study is limited by the amount of time students engaged in the engineering learning activities and the variability in instruction. Emphasis must be placed on increasing the amount of time students engage in the activities as well as the amount of time teachers spend on developing and implementing their respective units.

Unique to this study was the use of multiple data sources. Multiple sources provide “cross-data validity checks”\(^\text{16}\), and the “limitations” of one source “can be compensated for by the strengths of a complimentary one”\(^\text{17}\). In this study, the different methods frequently served to strengthen the findings. For example, a better understanding of the work of engineers revealed in a student’s interview was supported by gains on knowledge tests and accurate drawings of engineers at work. However, throughout the process, it was clear that the interviews played a pivotal role in truly exposing what the children knew. To illustrate, Ron’s scores in the post Knowledge Test items on the engineering design process were poor, leading to the conclusion that Ron’s understanding of this area was weak, yet his interview showed that he did master this topic. This illustrates the importance of using multiple data sources and in this case, specifically interviews, to make sure that the participants’ knowledge and perceptions are accurately portrayed.

The significance of this study suggests that engineering educators should consider not only multiple data sources (i.e. qualitative and quantitative) but also innovative data collection methods (e.g. identity scale) when examining how children learn and engage in engineering education. By doing so, engineering educators can instigate further research on how different factors interact with learning in engineering, which might potentially lead to changes in the ways in which engineering curriculum, educational programs, and instructional practices are formulated.

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Bibliography


