
AC 2011-850: GENDER AND ENGINEERING: USING PHOTO ELICITATION AS A METHOD OF INQUIRY

Katherine M. Morley

Katherine is an undergraduate student in Aeronautical Engineering at Purdue University. As a member of the Society of Women in Engineering, and a participant in the Women in Engineering Program at Purdue University, she took interest in feminist engineering research. She is particularly interested to learn how engineering is conceptualized and gendered.

Alice L. Pawley, Purdue University, West Lafayette

Dr. Alice L. Pawley is an assistant professor in the School of Engineering Education and an affiliate faculty member in the Women's Studies Program at Purdue University. She has a B.Eng. in Chemical Engineering from McGill University, and an M.S. and a Ph.D. in Industrial and Systems Engineering with a Ph.D. minor in Women's Studies from the University of Wisconsin-Madison. She is Co-PI and Research Director of Purdue University's ADVANCE program, and PI on the Assessing Sustainability Knowledge project. She runs the Research in Feminist Engineering (RIFE) group, whose projects are described at the group's website, <http://feministengineering.org/>. She is interested in creating new models for thinking about gender and race in the context of engineering education. She was recently awarded a CAREER grant for the project, "Learning from Small Numbers: Using personal narratives by underrepresented undergraduate students to promote institutional change in engineering education."

Shawn S Jordan, Purdue University, West Lafayette

Shawn Jordan is an Assistant Professor in the College of Technology and Innovation at Arizona State University. He received his Ph.D. in Engineering Education and MS in Electrical and Computer Engineering from Purdue University. His research interests include virtual cross-disciplinary engineering design teams in industry and pre-college engineering design pedagogy.

Dr. Robin Adams, Purdue University, West Lafayette

Robin S. Adams is an Assistant Professor in the School of Engineering Education at Purdue University. She led the Institute for Scholarship on Engineering Education (ISEE) as part of the Center for the Advancement of Engineering Education (CAEE). Dr. Adams received her PhD in Education, Leadership and Policy Studies from the University of Washington, an MS in Materials Science and Engineering from the University of Washington, and a BS in Mechanical Engineering from California Polytechnic State University, San Luis Obispo. Dr. Adams' research is concentrated in four interconnecting areas: cross-disciplinary thinking, acting, and being; design cognition and learning; views on the nature of engineering knowledge; and theories of change in linking engineering education research and practice.

Gender and Engineering: Photo Elicitation as a Method of Inquiry

Abstract

In this paper, we explore the application of photo elicitation as a method of understanding and changing the perceptions of engineering held by professors and undergraduate students of varying disciplines, including engineering and technology. Our research questions in this paper are:

1. How is engineering conceptualized by undergraduate students and professors? and
2. Using photo elicitation, how are these concepts and perceptions gendered?

The data set comprises a series of interviews including two individual interviews and one group interview. The study includes 19 participants, including ten women and nine men; participants came from engineering, technology, or health sciences disciplines.

Our study had 3 interview stages: 1) an individual interview where we asked participants to gather photos that answer the question, “What is engineering to you?” Each person then participated in a one-on-one interview explaining five of the photos they brought; 2) a group interview where participants were asked to share their opinions and thoughts about engineering using the photos as a way to initiate the conversation. Participants were invited to explain their chosen photos to the people in the group; 3) a final individual interview where we explored whether each participant’s views or thoughts may have altered or developed after having discussed the photos in the group.

This paper reports preliminary findings associated with the first data collection phase: the initial individual interview. For our theoretical and methodological frameworks, we used a combination of inductive coding with Shaffer and colleagues’ epistemic frame elements. In addition, we coded for outcome, relationships with others, and ways of thinking and doing. Results were analyzed for hegemonic gender markers and put into a broader engineering epistemological context. Results were also interpreted based on how the participants conceptualized and gender their perceptions. Initial findings have suggested that most professors and students have both similar and unique ways of defining engineering, and many included themes of teamwork and problem solving.

Introduction

Research on engineering epistemologies has been identified as one of five priority areas for research in engineering education¹ and parallels current research on the nature of science and scientific inquiry.²⁻⁴ Investigating beliefs about engineering may 1) provide implications regarding who enters and stays in engineering, 2) clarify critical connections between engineering practice and how we prepare engineers for the profession, 3) illuminate potential naïve conceptions of engineering, and 4) provide a framework for constructing curriculum and pedagogy that better aligns with current and future needs as described in such reports as *The Engineer of 2020*.^{5, 6}

For example, research on conceptions of engineering can help us understand how prior conceptions influence decisions to pursue engineering, and how learners identify self-fulfilling prophecies around potentially inaccurate beliefs about what counts as success or failure in becoming an engineer.⁷ Although a relatively new area of research, studies of engineering perceptions illustrate that pre-college students' associate engineering with physical construction (i.e., buildings) over mental aspects such as design thinking,⁸ and that practicing engineers perceive the profession as underutilizing the broad knowledge gained in academic settings.⁹ Dahlmann and colleagues⁹ found that technological areas such as engineering are perceived as “soulless”, “absent of social relevance”, “absent of interdisciplinary views”, and “disregard[ing] social skills.” Research on engineering beliefs can illuminate naïve conceptions (or misconceptions) of engineering as well as make visible diverse facets of engineering that may be more inclusive and representative of authentic practice.

The purpose of this study is to take an epistemological perspective regarding beliefs about engineering. The overall study investigates the following research questions: 1) what are the conceptions about engineering held by practitioners and undergraduate engineering students; and 2) how do conceptions compare across differences in engineering experience? Folk theories¹⁰ are implicit theories widely shared by members of a community and play an enormous role in individuals' understandings of the world and their behavior in it. As such, they may have more influence on practice than authoritative documents offering guiding principles because they provide prototypical examples of authentic forms of everyday practice and inquiry. The long term goals of this study are to use findings to consider issues around recruiting a more diverse study body and supporting deep conceptual understanding related to engineering thinking.

The project research questions and method were designed by a team of researchers with different disciplinary backgrounds and levels of expertise, including an undergraduate student, a graduate student, and three faculty members.

Research Design

The general aim of this study was to investigate knowledge regarding the nature of engineering [that students and faculty possess.]. Photo elicitation is a central technique for studies that focus on interpretations of “work” as well as social class and organization, community and historical ethnography, identity, and culture.^{11, 12} It is a qualitative inquiry approach that emphasizes what Geertz¹³ calls “thick description” – going beyond surface details to uncover deeper meanings. As such, photo elicitation allows immersion into others' worlds and worldviews and makes visible the meanings of lived experiences. As an example, Harper¹¹ notes that photos prod latent memory, sharpen memory and reduce areas of misunderstanding, respond to how people think visually, elicit longer and more comprehensive accounts than interviews, make visible the invisibility of interpretations that often involve assumptions about shared experiences, elicit values and beliefs, and connect to core definitions of the self to society, culture, and history.

For this study, participants were asked to collect photos that represented “engineering to you”. The collection of photos was followed by a photo elicitation interview in which participants were asked to explain the ideas and objects embedded in the pictures they've taken. Aspects of these study protocols have been piloted over several iterations including a large scale international effort to investigate conceptions of engineering from a Swedish perspective.^{14, 15}

Participants

Our recruitment strategy was developed to get a wide range and breadth of perspectives on engineering. We recruited participants for this study from four major groups: 1) through undergraduate research opportunities offered on campus in the summer; 2) through a multidisciplinary service-learning engineering design opportunity; 3) through an engineering study abroad program; 4) through a college of technology. Once people had expressed their interests in participating, we asked them to complete a background survey about their engineering experience, as well as demographic and academic information.

Over the course of the project, we interviewed 19 people, although not all people participated in all three phases of the project. The result of this patchy participation affected the potential diversity of the results we are able to report. Participants were paid \$5 for completing each interview, so could earn up to \$15 if they completed all three interviews. Table 1 outlines some demographic information about the participants in aggregate, to protect their anonymity.

Men	9
Women	10
White ethnicity (self-identified)	14
Non-white ethnicity (self-identified)	5
Undergraduates	18
Graduate students	1
College of Engineering	11
College of Technology	6
Multidisciplinary service-learning engineering design project	2
Disciplines represented: Communication & Music Theory, Aero Engineering, Mechanical Engineering, Civil Engineering, Engineering Education, Chemical Engineering, Building and Construction Management, Environmental Engineering, Health Sciences, Agricultural and Biological Engineering, Electrical Engineering, Computer and Information Technology	

Method

Photo elicitation as a research method

Photo elicitation is the “idea of inserting a photograph into a research interview.”¹⁶ Photos may either be taken by the researcher for a more theory-driven study, or by the participants for a more inductive study. The content of the photos is not as important as what the participants say about them; the primary goal is to use the photos as tools to stimulate the expression of ideas.

Carlsson¹⁷ has argued that this researcher-centric viewpoint is not consistent with participants’ views on the process, as studies of this method have shown that participants may spend a lot of time trying to get the right angle and distance in order to correctly capture their ideas.

Photos can act as visual inventories of objects, people, and artifacts. They can also “depict events that are part of collective or institutional paths”¹⁶ (e.g., events that have happened at a different point in time). Carlsson¹⁷ has argued photos can provide a window into “the way people experience and relate to the world surrounding them,” meaning they can reveal intimate dimensions of the connection between self and society, culture, or history, and perhaps even “complex expressions of the photographer’s relation to the world.”

A variety of reasons exist to use photo elicitation in research. Above all, Harper¹⁶ has argued that, “images evoke deeper elements of human consciousness than do words.” Photos can stimulate memory in different (and unknown) ways compared to verbal interactions, potentially because they allow people to reconnect with the past in the present in different ways. These positive effects can, in turn, increase both the quantity and the quality of explanations provided by participants.

Photo elicitation can build a communication bridge (and rapport) between the researcher and the participant,¹⁷ because images act as a common ground that can be understood by both parties. This in turn provides structure and reduces the awkwardness sometimes encountered during interviews where the researcher and participant do not know each other well. They also encourage participants to become storytellers, since cultural norms dictate that people use photos to tell others about events that occurred in the past.

Researchers have made other arguments about the value of using photo elicitation in studies, including: photos can help describe situations more easily,¹⁷ can extend “personal narratives that illuminate viewers’ lives and experiences, especially when viewed in a group setting;”¹⁸ can help prompt interviewers to ask specific questions they may not have otherwise considered including asking for data that may be “invisible to the researcher but apparent to the interviewee” (Schwartz 1989); can help participants reflect on their beliefs and express their feelings;¹⁷ and can triangulate conclusions in connection with other data collection methods.

However, there are considerable potential challenges associated with photo elicitation as a method. The technological process can be considerable, including how to collect, share, store images when participants have a multitude of technologies at their disposal and may choose different methods than each other. Participants may lose the study’s cameras or other technology, or be unskilled at taking photos, or get frustrated with the flash or their (in)ability to capture close-up photos for far-away objects with a cheap camera. They could be embarrassed by the photos they have taken, although this can be limited by allowing participants to select photos they want to discuss. There are also epistemological challenges, as, for example, that photos represent “what is seen” and parts of people’s beliefs are not always visible. For this reason, the photos were analyzed within the context of how the participant explained the photo. In addition, photographs do not necessarily represent “Truths” or “Reality,” although the participant may argue they do; these experiences should be considered in the process of analysis. Finally, as Clark-Ibanez¹⁸ argues, “Researchers should be aware of differing definitions of what belongs in a photograph,” making the process of the interview critically important for the overall analysis.

We worked to minimize these challenges by providing more choice and opportunity to participants – for example, they could choose which 5 photos to bring (and therefore didn’t need to show us a whole “roll” of photos), they could choose photos from online (minimizing any technical difficulties they had with photography) and they were able to explain their intent through the interviews, minimizing our misinterpretation of the framing of the photograph. In addition, some photo elicitation technical challenges have been minimized with the incorporation of sophisticated yet simple digital cameras into many students’ daily technology, such as as part of mobile phones.

Epistemic frames as a structure for analysis

In thinking through the analysis of this project's data, to be described below, we have drawn heavily on the "epistemic frame elements" introduced by the Epistemic Games research group (epistemicgames.org). This group develops then researches games designed to help school-aged children learn to "think like a professional," developing games for engineering, urban planning, and journalism. The epistemic frame helps researchers think through what "thinking like a professional" actually means in the context of people's speech and actions. Shaffer and colleagues¹⁹ argue (p. 4):

The epistemic frame hypothesis suggests that any community of practice has a culture [...] and that culture has a grammar, a structure composed of:

- Skills: the things that people within the community do;
- Knowledge: the understandings that people in the community share;
- Identity: the way that members of the community see themselves;
- Values: the beliefs that members of the community hold;
- Epistemology: the warrants that justify actions or claims as legitimate within the community

[...]The epistemic frame hypothesis claims that: (a) an epistemic frame binds together the skills, knowledge, values, identity, and epistemology that one takes on as a member of a community of practice; (b) such a frame is internalized through the training and induction processes by which an individual becomes a member of a community; and (c) once internalized, the epistemic frame of a community is used when an individual approaches a situation from the point of view (or in the role) of a member of a community.

While guided directly by some of these arguments, we have found it necessary to use some interstitial categories that may help us think through connections more strongly as we progress through the analysis. We will discuss this further later in the paper.

Hegemonic gender as an analytical tool

In this study, we were interested not in whether women and men brought different photos from each other, or described different stories about engineering, but whether the photos and the stories themselves represented the broad diversity of work that can be considered engineering, or whether they followed fairly conventional lines marked by gender.

It would be a disservice to try to summarize the extensive history of gender dualisms and their interpretation and study in a short paragraph, but we will endeavor to provide a taste to help situate the reader unfamiliar with this literature. Second-wave feminism is acknowledged²⁰ as having significantly disrupted historical dualities deeply rooted in Western history and philosophy that had mapped women's and men's lives. By dualities, we mean those (not unproblematic) binary characteristics and spaces where women were connected with one pole and men the other; strong historical and cultural literatures describe as commonsensical such hegemonic dualities including, but not limited to:

public/private	clean/dirty
civilization/nature	order/disorder
day/night	rationality/emotionality
strong/weak	war/peace

mind/body
political/personal

work/family
male/female

All the terms on the left half of the slash were represented by men and their perview, while the right half were women's domains. Mack-Canty²⁰ (among a great many others) describes how second-wave feminists not only fought for women's rights to engage with the "male" half of the dualities and participate in public life, highly valued paid work, but eventually began to problematize the very notion of such dualities. Women's studies scholars tend to acknowledge that a key tenet of third-wave feminism is the developing and use of intersectionality as a theoretical approach, where people's identities are situated at the intersection of a variety of social categories' "axes"; an additional component is the recognition that gender is a fluid identity rather than simply male/female, that individuals may identify as multiple and sometimes conflicting gender identities, that these identities don't map to simply two genders, that they may change with time, and they also need to be understood intersectionally with race, class, sexuality, nationality, age, and a variety of other categories.²¹⁻²³

In engineering education research literatures, gender is usually used as a binary category that is strongly linked to women's historical and persisting underrepresentation in engineering. Studies of gender regularly compare men's performance on various instruments, experimental procedures, or interview protocols to women's in order to try to understand why comparatively fewer women than men persist in engineering programs, for example. Indeed, in many engineering education research spheres, the word "gender" stands in for a study of "women." *This kind of analysis is not what this paper is about.*

Instead, we use gender situated as a category of historical analysis²⁴ to understand how our study participants may map gender onto their conceptions of what engineering is. There is also an extensive literature that has investigated the relationship of gender to different forms of technology,²⁵⁻²⁸ and that has studied the gendering of engineering in terms of concepts, content and ways of being;²⁹⁻³² indeed, one of our earlier research projects argued that, despite engineering's connection with "problem solving," our conception of engineering has tended in important ways to focus on paid work contexts, producing things at large scale and volume, for profit, and in commercial, industrial and military context, and not domestic contexts, small craft-level operations, not-for-profit or community service contexts.³³ Finally, with particular relevance to this project, we are guided by a critically important literature³⁴⁻³⁸ noting the scientific and engineering training of women in home economics programs, where, were context not considered, the content and skills would have been considered "engineering." But context is indeed relevant: these women were redesigning electrical circuits for toasters, not industrial heaters, they were designing ventilation systems for ovens, not power plants, they were planning the layout of kitchens, not auto assembly lines. Using Shaffer and colleagues' framework, we might say that these women had skills, knowledge, values, and epistemologies of engineers, but lacked identities as engineers, both in how they identified themselves and how others identified them.

With this project, we were interested in how gender was represented both in the content participants' interviews -- in their stories of what engineering was or was not -- and in content of the photographs that they brought. What contexts were represented, and were those spaces

historically associated with women’s labour that could be considered engineering included? We set out a series of qualitative categories that could help us explore gender content including the setting/context, the people who were represented and how they were represented, the relationships between people imaged, and any objects and what kinds of work or purposes they represented. Such an analysis is similar to the “Draw a Scientist”³⁹⁻⁴⁴ or “Draw an Engineer”⁴⁵ tests often conducted with children to see what sorts of gender markers are used to signify a “scientist” or “engineer.” For this paper, we broke out the hegemonic gender dualisms into these categories, and catalogued contexts, people, objects and relationships among all of them for each photograph included in participants’ interviews.

Project procedures

Participants were invited to participate in a first “pre” interview, and to bring photos with them that answered the question “What is engineering to you?” Participants were allowed to gather these photos in any way they chose, including taking their own photographs.

We initially interviewed each participant separately. We had told participants to bring 5 photos to the interview, but many brought more than 5, so were asked to pick five of the photos that they had brought to talk about more in depth in the interview. Each photo was numbered by the order in which the participant wished to discuss them. Participants were asked to order the photos, then to explain that ordering. The participant was then asked to describe each photo using the same set of general questions as outlined in Table 2. These questions were designed to probe for the participant’s views on engineering without prompting specific answers.

Table 2: Initial interview questions, asked for each photo.
<ol style="list-style-type: none"> 1. Let’s look at the first/next photo, <photo number>. What is this photo about? 2. Why does this photo represent engineering to you? <i>Probes:</i> Why did you decide to bring this photo? What do you like or dislike in the photo? 3. (after the first photo) How would you compare this photo to the ones we’ve already talked about?

After discussing each photo, each participant was asked to describe his or her thinking on “what engineering is to you.” The ordering of the photo discussion before this point was intentional in order to see if the participant referred back to the photos, or whether there was a depart from the photos. The interviewer asked some final questions of the participant, outlined in Table 3.

Table 3: Final questions from initial individual interview.
<ol style="list-style-type: none"> 1. First, if you had to provide one more photo, what would be in it, and why? 2. Looking at things from a high level, what would you say “engineering” is, for you? 3. Do you think your views on engineering have changed over time (if so, in what way; if not, why do you think this is)? 4. Can you think of a specific time or issue that challenged your view of what “engineering” is? 5. What is something that you consider engineering that other people might not? 6. What is something that others might consider engineering that you do not?

The interviewer then asked for confirmation that there was no information included in the photos that the participant would not want published, and whether they had any final thoughts to add.

To provide context for the broader study, we describe what happened after the individual interview, although the data reported here are from the initial individual interview. After completing a set of several individual interviews with about 5 people, we scheduled a group interview. We constructed the groups to get variation in background, including information from the initial background survey, including varying the groups by major, year in school (where appropriate), experience in national and international travel, and engineering experience (whether they were a student or instructor, whether they had had internship or co-op experiences). The five photos that each participant brought to the individual interview were renumbered for easy reference during the group interview. We asked about the participants' thoughts and views on engineering using the photos to prompt thoughts and spark discussions among the participants. After the group interview, we set up an individual "post" interview with each participant to discuss what each participant was taking away from the group interview experience, and what the participant would now describe engineering as, in order to determine how or whether the participant had changed her or his thoughts or views of engineering.

Data analysis procedure

Each of the interviews were recorded and transcribed verbatim by a professional transcriber (editing out small crutches of speech such as "ah" and "um" as they did not contribute to our analysis).⁴⁶ After transcription, the transcript files and electronic copies of the photos that each participant brought were loaded into NVivo 8. We conducted two forms of coding: a deductive pass, connected with Shaffer and colleagues'¹⁹ epistemic frame structure; and an inductive pass, where we looked for additional ideas and themes not covered by the epistemic frames elements, as well as categorizing within each theme of the framework.^{47, 48} More specifically, we coded "skills" and "knowledge" together as it is not always apparent from our participants' interviews what the difference is, we coded "identity" directly, and we connect "values" with "ways of thinking." In addition, there were key phrases we felt were important to capture from our participants' interviews that didn't seem to fit well yet into the epistemic frame elements, so we coded them as "ways of doing" (perhaps different than skills, to our minds), "tools," "purposes" or "outcomes," and "relationship with others" (which we felt a little different from identity, at this point). We anticipate as our analysis progresses that these ideas may resolve back into the epistemic frame elements, but are hesitant at this preliminary phase to make those connections.

We have treated participants as individual cases,⁴⁹ where we drafted a case about each participants' series of interviews from the participants' transcripts and from notes taken by the interviewer through the interview. We drafted this into an internal technical report as part of our data audit,⁴⁷ which helped us look for particular themes that individuals repeatedly brought up within their series of interviews. In addition, we also have looked across cases for cross-cutting themes that multiple individuals raised. Some of these themes have been presented at the Frontiers in Education conference.⁵⁰

Discussion of analysis

We report here on the data collected as part of the initial "pre" interview, where the participants brought their pictures that represented engineering to them and discussed them with the interviewer. As a result, these data represent themes seen across cases.

Epistemic frames analysis: commonalities

Within our themes of tools, values, purpose, relationships to others, ways of doing, identities, outcome and skills or knowledge, we found several similarities in the types of subthemes that participants used. We used these similarities to further analyze how students and professors conceptualize what engineering is to tell us a more detailed story about the engineering epistemologies held by people in academic engineering.

We categorized the kinds of *tools* described by participants into four different groups: machinery, planning, design tools and constructive tools. Machinery included objects from diggers to computers, and accounted for about a third of the kinds tools mentioned. Planning also represented a third of the tools used to describe engineering, and included blueprints, modeling and diagrams. Design tools include items like rulers and compasses, and seemed to be tools related to creating the planning tools of blueprints and diagrams; design tools formed about a fifth of the mentions of tools across all participants. “Constructive” tools include objects like pipe wrenches and glue guns, and, surprisingly to us, made up just over a tenth of all the kinds of tools discussed in the pre-interviews.

Six of our 19 participants mentioned something having to do with values in their interview. We broke engineering *values* into six different values: precision and accuracy, creativity, logic and practicality, progress, efficiency and ethics and morals. Of these values, precision and accuracy, and progress each comprised of a quarter of the values discussed by the participants, while the other values had an eighth of the responses each.

We divided the *purpose* of engineering into five main ways discussed by participants: a discipline, engines, structural forms, electrical ideas and conceptual ideas. “Discipline” refers to moments when the participant used a photograph to show the purpose of a particular discipline of engineering that they explicitly mention. This accounted for one seventh of all the purpose framework references. Disciplines specifically mentioned were mechanical, electrical, civil, and biomedical engineering. Engines were used to describe the purpose of engineering across multiple cases several interviews. ‘Engines’ refers to references that we vehicular in nature. This included references of Bobcats and cars. Structural forms were used in the same way but to refer to bridges and buildings. There were references to a structure used in the biomedical engineering field to expand an artery or in relation to an electrical form. The last main way participants described the purpose of engineering was in a conceptual way, mainly through problem solving, creation and improvement. These concepts accounted for more than three fifths of the ‘purpose’ framework. ‘Creation’ alone accounts for over a fifth of the purpose references. The remaining concepts each account for about one fifth of the purpose framework references.

The *relationships to others* category was divided into six kinds of relationships with people or the public. An antisocial relationship was described by a total lack of social contact with other people. A teamwork relationship was described between engineering disciplines, and another person described a client relationship. The teacher-learner relationship was discussed as being double-sided, in that an engineer will be both at one time or another during course of his or her engineering career. Engineers were also described as being influential, and ‘philanthropy’ was mentioned when talking about engineers and their relationship with the public.

The *ways of doing* framework was broken into nine different categories based on participant responses. The most frequently discussed “ways of doing” were design and process. Each of these categories comprised about a fifth of the ways of doing references. Participants would mention design to describe what it took to create something such as a parking garage or motorcycle. For process, participants would mention a very specific process or step of a process. A practical way of doing something was mentioned among this framework’s references one sixth of the time. Teamwork was also mentioned as a way of doing engineering work. This accounts for about one ninth of the ways of doing references. When discussing how something was done, the root word of complicated was used in less than 8% of the references. Experimental repetition was mentioned in less than 8% of the references as well. In another less than 8% of the references, the participant discussed accomplishing something by doing something in a lab. The idea of ‘progression as a way of doing’ was represented in fewer than five percent of the references, as did ‘precision’ and ‘accuracy.’

The engineering *identities* framework was divided into four main categories; “Dilbert,” special language, lab coats and importance. Dilbert is a comic strip character in a strip of the same name that depicts an engineer as being socially awkward and cowardly. A picture of Dilbert was discussed by two separate participants in their pre-interviews to show how engineers live boring lives and lack social skills. Another participant said that engineers have their own way of speaking, and still another brought up lab coats as engineering clothing. Another participant brought a personal picture of her father, who is an engineer. In the picture, the father is making a comical face at the camera, which was important to this participant to include because she said it showed how engineers are a weird and nerdy group of people. There was also a participant that brought a photo of the engineering buildings at Purdue University. The purpose of this photo was to show how the participant felt engineering is important, as this photograph was to show how much space Purdue University dedicates to engineering on campus.

We divided the engineering *outcome* framework into four groups. Half of the references discussed an actual final product like the Empire State Building. About one third of them referenced the outcome as a system of different smaller parts. ‘Emotion’ and ‘triumph over nature’ each accounted for about a tenth of the outcome framework. Emotion referred to engineering creating an outcome of excitement. An example provided by participants of the ‘triumph over nature’ theme is the Palm Islands in Dubai, human-made islands in the shape of a palm tree.

We found six subthemes throughout the *skills or knowledge* framework. The skills discussed by the participants included social, planning, creativity and innovation, logic, math/science/ physics and problem solving. Only one tenth of the framework references the poor social skills that engineers are believed to possess. Planning skills were discussed in less than a one fifth of the references. Creativity and innovation skills accounted for about a quarter of the skills and knowledge framework. Logic only comprised less than a fifth of the framework. Math, science and physics dominated a quarter of the framework. Problem solving skills were only mentioned in about a tenth of the framework.

Epistemic frames analysis: variation across participants

Within each of the interviews, the participants vary in the frameworks that they discuss. Only one participant touches on all eight epistemic frame elements. One participant focused on as few as two of the frameworks. On average, the participants would touch on between 5 and 6 of the epistemic frame elements in their interview.

Many participants selected each photo they talked about with the intent of representing only one aspect of how they wanted to answer the question, “what is engineering to you?” They wanted each photo to show a different facet of their view of engineering, which meant, through five photos they could represent a multidimensional picture of engineering. However, there were a few participants who would try to theme the selection of their photos with one main overarching idea they felt best defined engineering for them. Even with the single idea guiding the photo selection, these participants would inevitably discuss other parts of the framework that were still represented in each photo. While participants tended to select photographs one or the other of these ways, the average number of elements discussed by each participant is still relatively high across both because even the participants who tried to keep a common theme across their photos expressed more than one aspect of engineering within their photos.

The coding categories we used are the same as in the previous section. It was not uncommon for a participant to talk about several different subthemes within the same category or element. This was especially common for the participants who had selected photographs based on one main idea. We saw highest variability of ideas in the ‘ways of doing,’ theme, purpose, values, and skills or knowledge frames. In the ‘ways of doing’ framework, participants generally varied across two or three subthemes that we saw were still related to ‘ways of doing,’ although some participants used as many as four. The participants that spoke about the ‘purpose’ of engineering usually talked about at least two different ideas within this theme. Participants chose to discuss between one and two themes on average per photograph, although participants that discussed engineering skills and values would talk about at least two or three themes.

This variation was less common in some frameworks than others. It was not common in the ‘tools’ category -- most participants expressed simply one idea of what kinds of tools engineers used. The framework for ‘relationships with others’ also did not vary much -- there were only a small set of relationships that participants collectively expressed. Outcomes also had little variation -- most participants only mentioned a single final product even if they discussed multiple objects or pictures. Most participants only invoked the ‘identity’ theme using only one subtheme, without variation -- only one participant spoke to 3 separate identity themes: Dilbert, engineering having a special language and her family member’s connection.

We found that sometimes participants would contradict themselves while explaining the reason for choosing to bring that photograph. For example:

E10: The photo’s about two people working on a car. So, I’m assuming that it’s mechanical engineering. Um, I’m thinking that they’re building the car, or designing the car. I don’t think that they’re fixing it. I think that they’re building it. Okay.

Interviewer: And why does that represent engineering to you?

E10: I think part of mechanical – I’m not really sure what the term, “mechanical engineering” is all about, but when I did research on Google, so part of it just uh, fixing automotive stuff. So that’s why it represents engineering to me.

This participant explains that the people in the photo are not fixing the car, then says that he or she brought the photograph because mechanical engineering is “fixing automotive stuff.” This may be evidence that some participants are still developing, or at least reflecting⁵¹ on their ideas about engineering during the interview.

In general, we found participants mentioned between 2 and 8 different categories. Broken out by person, this means one person mentioned two categories, two people mentioned 3 categories, 4 people mentioned 4 categories, 3 people mentioned 5 categories, 5 people mentioned 6 categories, 3 people mentioned 7 categories, and 1 person mentioned 8 categories of ideas.

Hegemonic gender binaries analysis

As described earlier, we categorized context, people, objects, and relationships in each photo discussed by a participant, and looked for evidence of different gender binaries. We were pleasantly surprised that we saw fewer binaries recognizable than we expected, or that one might have seen a decade ago. Gone are the plethora of images of pocket protectors and “geeks” that plagued researchers in earlier works,³² although, in the interviews, one participant talked about engineers as being antisocial, two talked about Dilbert to indicate engineers lived “boring lives” and lacked human interaction.

We begin with a discussion of the people represented in the images. For our 19 participants, 14 brought photos that had people of any kind in them. Nine people brought images that pictured solitary boys or men, and only one person brought a photo of a solitary girl or woman. Seven people brought photos with a mixed-gender group represented. There were 5 photos that had people imaged but we could not tell what gender they were performing. Several people brought in pictures of Dilbert, as mentioned earlier, or other cartoon characters. However, the starkest result we saw was that, out of all 95 of the photos brought to the pre interviews, 59 (roughly 60%) of them had no people represented at all. Indeed, three people brought *only* photos without people, and 15 of our 19 participants brought three or more photos with no people in them at all. While we are pleased to see images of women included through the mixed gender groups, we are struck by the high number of people-less photos.

We were pleased to note that, when there were groups of people, no pictures seemed to represent a competition between individuals, and instead represented some form of collaboration. For the most part, when people were represented, they were not the grease-covered blue-collar workers mythologized of the past, but instead were presented as clean, often professionally dressed (one in a lab coat), and eight people brought images of people using tools in contrast to “brute strength” to accomplish a task. Where there were multiple people, they were often represented in co-worker relationships (12 of the photos), in contrast to friendships (0) or family (1); three photos captured passersby, who happened to be in the background rather than forming the subject of the photo.

Moving to consider background more directly, we note that all participants brought at least one photo identifiably occurring in the daytime, and that a third of all the photos collected were also daytime scenes. One person brought one photo taken at night, and a different person brought one photo at a transition time (sunset or sunrise). Sixteen people brought photos taken inside, and just under a third of all the photos were taken inside. On one hand, we could argue that daytime photos might reflect the active, work world aligned with certain conceptions of masculinity, but we also recognize the technical benefits taking photos in daylight provides -- it is easier to take good photos with enough light around, with perhaps limited electronic equipment. As a result, we do not ascribe much gendered character to the timing of these photos.

Contexts of the photos tended to be a mixture of industrial/commercial and domestic contexts, although generally the domestic contexts were interpreted as “background” to the photo (a photo taken of a car in an apartment parking lot, a picture of a cell phone next to a computer on a personal desk) and not the focus of the image. In other words, we saw images of diggers, of office buildings, of large reactors, but no kitchens. Generally we saw images situated in public space (17 people brought photos of public spaces, comprising over a third of images) more often than private spaces (14 people brought almost a quarter of photos situated in private spaces). We had anticipated the exclusion of domestic technology in considering what engineering is, and we saw this anticipation supported; however, we had expected more skew in the contexts than we have reported here.

We have described already many of the objects we saw in the images -- tools of various kinds, accomplishing various sorts of work, built things, machinery and so on. Nine people brought images of some kind of engine, 8 brought images of computers or computing devices, and 5 brought images of robots. Only three images had any obvious connection with war or military technology, while 6 we felt represented more peaceful endeavors, and only 5 images obviously represented some kind of dangerous situation.

Whether looking at objects or at people, we saw that 14 participants brought 24 (about a quarter) photos of some kind of action or activity occurring, while 18 participants brought 54 images (over half) of a passive scene. Two people brought only photos of a passive scene, and there weren't any participants who had all their photos represent an active scene.

Taken together, we admit being surprised by the diversity of images presented and how they did not seem to be easily slotted into hegemonic gender dichotomies. As we put the images in context with the interviews, we do not feel we have overly ascribed meaning to objects or people that our participants did not intend. However, we continue to hope that people may begin to see more strongly engineering as playing a role in their domestic private lives, in the structure and function of their kitchens and homes, in caring for the very young or for elderly people in our or their homes, or in other work across the globe that women disproportionately continue to do.^{33, 52}

Conclusions

In this paper, we described the research method of photo elicitation, and articulated two content analysis methods used to analyze data collected through photos brought by and interviews with a set of undergraduate and graduate participants. We hope we have demonstrated the potential for using this method to generate rich descriptions about what participants wanted to share

engineering meant to them. Subsequent work on preliminary analysis described here will verify the coding structure and reliability for both theoretical frameworks (epistemic frame elements and hegemonic gender dualities), and contrast the “pre” interview photos with those discussed at the group interview and the “post” interview. For the project, subsequent research analysis will involve answering our third research question: how can photo elicitation be used as a pedagogical tool to change engineering epistemologies? We are intrigued by the breadth of ideas represented in these data (interview and photo-based), and want to connect back with the original theory motivating this research of exploring naive constructions and folk theories of engineering.

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