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Emily Dommermuth
University of Colorado Boulder, emily.dommermuth@colorado.edu

Linds W. Roberts
University of Colorado Boulder, linds.roberts@colorado.edu

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Listening to First Generation College Students in Engineering: Implications for Libraries and Information Literacy

Emily Dommermuth, University of Colorado Boulder
Linds W. Roberts, University of Colorado Boulder

Abstract

First-generation college students (FGCS) in engineering bring a wealth of knowledge to their academic and social experiences in higher education, in contrast to deficit-based narratives that students are underprepared. By listening to FGCS' own experiences navigating higher education and using information literacy in their project-based work, librarians and educators can better understand students' funds of knowledge, social capital, and identities, as well as the institutional barriers that must be removed. This paper shares interview findings with (n = 11) FGCS and suggests implications for professional practice that are relevant to information literacy for design, project-based, or practitioner focused disciplines.

Keywords: information literacy, first generation college students, design-based education, project-based education, engineering education

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Listening to First Generation College Students in Engineering: Implications for Libraries and Information Literacy

The library and information science (LIS) literature highlights a growing need for academic libraries to understand and accommodate the experiences of first-generation college students (FGCS or FG) (for a summary, see Ilett, 2019a). Generally, FGCS have parents who did not complete a higher education degree; however, they are not a monolithic group (Toutkoushian et al., 2018). Students without a family history of college-going are often members of groups who have been systematically denied access to higher education based on race or ethnicity, social class, language, immigration status, and additional social categories. Thus, FGCS status is often a reflection of long-standing societal oppression. In higher education, there are often deficit-based assumptions that FGCS are not college ready, resulting in barriers students experience in gaining entry to, and existing in, higher education systems (White, 2016).

The engineering profession and engineering education have increasingly become systems that exclude FGCS. As Smith and Lucena (2016a) illustrated, "engineering training was slowly taken out of the shop, off the jobsite, and into the classroom" (p. 205), which resulted in an elite, credentialed, professional education. A deficit-based perspective on FG and underrepresented students in engineering has focused on individual traits, instead of examining the ways that teaching and learning are organized to conclude that students are "not cut out for engineering" (Secules et al., 2018, p. 56). An asset-based perspective shifts from placing the onus on students needing to be college ready to focusing on colleges being student ready (White, 2016). Librarians and educators must become aware of these barriers and shift them. An asset-based perspective focuses on the strengths students bring to their education.

In order for librarians to focus more on becoming student ready, we explored the information literacy (IL) and information behavior of FG engineering students via semi-structured interviews at the University of Colorado Boulder (CU Boulder). For the purposes of this article, the authors conceive of IL as the set of "abilities in which students are consumers and creators of information who can participate successfully in collaborative spaces" (Association of College and Research Libraries, 2015). To explore IL more precisely among FGCS in engineering, we focus on students' information behavior, or the ways they

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interact with information, especially the ways they seek and utilize information (Bates, 2018). Students' information behavior demonstrates the ways they are enacting information practices, where information is mediated through sociocultural layers that include power, privilege, tradition, disciplinary context, and access to information (Fulton & Henefer, 2018). Rather than conceiving of IL as a binary that students have or do not have or as a competency that librarians can "give" students, the authors start from the conviction that everyone has information literacies that relate to their information behaviors, and these literacies may be more or less adapted to different information landscapes.

Because students' identities and motivations impact their learning and their IL (Cahoy & Schroeder, 2012; Nichols Hess, 2015; Jacobson & Xu, 2004; Klentzin, 2010), we explored these research questions:

- RQ1: How do the intersecting identities of FGCS relate to the strengths students bring to their practice of engineering?
    - RQ1a: How do students' identities inform social communities?
- RQ2: How do FG engineering students describe their information practices?

Literature Review

FGCS and Engineering

Within the literature on FGCS studying engineering, three areas that focus on students' strengths and assets include research on students' funds of knowledge, social capital, and identities. Funds of knowledge research highlights the connections among students' learning and experience from within and outside of the classroom, and prioritizes students' interests, questions, and active participation in seeking answers (Moll et al., 1992; Smith & Lucena, 2016b). This concept came from work with K–12 educators who were coached to conduct information interviews with students' families that helped them understand the significant sources of knowledge and expertise within Latina/o communities that can be sources of pedagogical connection to and from students' lives (González & Moll, 2002). This concept has since been adapted to a range of contexts around the world (Rios-Aguilar & Kiyama, 2018). Research has found FG engineering students developed funds of knowledge in "designing and solving problems in the midst of scarcity" (Smith & Lucena, 2016a, p. 208), empathizing, and "recognizing the sociotechnical nature of engineering" (Smith & Lucena, 2016a, p. 212), as well as in connecting experiences, tinkering knowledge, community

understanding, and collaboration (Verdín et al., 2019). When students' prior knowledge and experience was connected to engineering curriculum, students' confidence about performing well in engineering was solidified, which in turn had a positive impact on sense of belonging in the classroom and certainty of graduating with an engineering degree (Verdín et al., 2020a, 2020b).

Students' social capital comprises resources embedded or accessed through their social networks and relationships (Lin, 2001). Studies have found that individuals from a student's family, peer, high school, and university communities can all provide social capital for FG engineering students (Martin et al., 2020; Pfirman et al., 2014). These individuals provide emotional or motivational support, community, and information in navigating higher education, completing academic work, and exploring career options. Social capital has benefits for FGCS engineering students including positive beliefs about their engineering belonging and ability, persistence, expectations for their careers, and development of engineering-related networks (Dika et al., 2015; Simmons & Martin, 2014). Research has specifically explored the social capital contributions of FG students' families, including acting as a sounding board for decisions, inspiring motivation, encouraging their students to seek fulfillment in their career, providing emotional support, assisting with college admission, assisting with financial decisions, and holding aspirational capital or hope that their FGCS would attend college (Coronella, 2020; Simmons & Martin, 2017).

While this study and our literature review focus on FGCS studies, students' additional identities were also salient to their *engineering identity*, defined as students' persistence and motivation to enter and continue in the engineering discipline. Research has shown FGCS to have complex reasoning for choosing the engineering field. For instance, financial stability may be part of FGCS' motivation to study engineering, and the desire for financial stability may include supporting not just self but family (Coronella, 2020; Trenor et al., 2008). Other studies demonstrated that FGCS are motivated to be engineers because they have a desire to help others, to solve problems, or to invent or design things; an interest in math and science; and a desire for financial stability (Coronella, 2020; Smith & Lucena, 2015; Verdín & Godwin, 2017, 2018b, 2019).

Using the lens of intersectionality, Verdín & Godwin (2018a) found that for FG Latinas in engineering, gender and ethnic identity were important in the context of engineering. Other studies found that the social capital of Black and Latina/o engineering students contributed to student persistence, leadership skills, sense of community, and role models in

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engineering (Revelo, 2015; Ross et al., 2021; Samuelson & Litzler, 2016). In studies with low-income, FG engineering students, Smith and Lucena (2015, 2016b) illustrated how students drew on the funds of knowledge from their backgrounds to belong in engineering. Researchers have also looked at how students with disabilities are experiencing STEM, what shifts can broaden accessibility to allow for their greater participation and agency, and how these modifications benefit all students (Franklin et al., 2018; Menzel et al., 2019; Polmear et al., 2021; Scheidt & Godwin, 2017).

Engineering Information Landscapes

The engineering profession and engineering education have long been known to have discipline-specific information practices, including viewing people as sources, using library sources less, and prioritizing proximity to information to a greater degree than among other types of scientists (King, 1994; Taylor, 1991; Whitmire, 2002). More recent research with professionals and students has affirmed a heavy reliance on human social networks, or seeing people as sources (Allard et al., 2009; du Preez, 2015; Hertzum & Pejtersen, 2000; Jones, 2017; Saleh, 2012). However, research has suggested significant gender-based differences in how professional engineers seek knowledge from one another and view themselves as knowledge creators (Poleacovschi et al., 2021; Tenopir & King, 2004). Cultural and geographic differences are also known to influence how engineers seek, find, and exchange information (Guo, 2008; Milewski et al., 2007; Pevneva et al., 2017; Tenopir & King, 2004).

Tenopir and King (2004) traced major shifts in engineering education in recent decades towards human-centered and team-based learning that necessitates integrating a wide range of information-seeking and communication skills. Mercer et al. (2019) offered a helpful review of the literature on engineering students' information behavior, affirming parallels between engineering students' information practices and those of professionals as well as the close ties to design thinking and information practices. Within the context of design-based work, defined as hands-on projects where students use design thinking to solve engineering problems, engineering students gather information at multiple stages of the design process, including through site visits and examining existing structures or projects (du Preez, 2015; Jones, 2017; Mercer et al., 2019). Students also value a much wider range of sources than may be used in other disciplines (Mercer et al., 2019; Saleh & Large, 2011). In terms of evaluating information, practicing engineers and engineering students may be prepared to satisfice, or accept lower-quality online sources that are more readily available

and seem to fulfill an information need (Allard et al., 2009; Jones, 2017; Mercer & Weaver, 2021; Saleh & Large, 2011).

Recent research has examined the collaborative information practices of engineers and engineering students (du Preez, 2015; Saleh, 2012; Saleh & Large, 2011). In a longitudinal study with undergraduate engineering teams, Saleh (2012) found that engineering students' collaborative information seeking increased as their perceptions of task complexity increased and that a shared understanding of information needs was vital to the group's synthesis activities, which were, in turn, foundational to their success within design projects. Among engineering students participating in multi-year racecar design competitions, knowledge management of team information through digital archives was found to be crucial to teams' success and continuity (Jones, 2017). All of these features make up the landscape of engineering IL and may share aspects of other design-based or practitioner disciplines.

The majority of the literature on the IL of engineering students focuses on case studies of instructional interventions. Phillips et al. (2018) conducted a systematic literature review for IL interventions for undergraduate engineering students, and they called for more research that measures the effectiveness of IL interventions to gain a better understanding of engineering students' IL skills. At the time of writing, only one article has touched on the intersections of FGCS, IL, and the engineering discipline. That study identified a negative correlation between students' grade on an IL assignment and their FG status (Johnson & Mentzer, 2019); however, we note that the methodology employed might not be relevant to discipline-specific engineering information practices. The present study aims to address a gap in the literature around how FG engineering students experience and describe information practices as it relates to their discipline and to navigating the university.

Methods

Research Protocol & Analysis

As part of a larger multi-site research study (Couture et al., 2021), the authors interviewed FGCS about their experiences transitioning to college and with academic libraries. The larger study was designed using an asset-based framework that views students' lived experiences through the lenses of their strengths. The study received IRB approval from each participating institution. Students were recruited for the study via email to campus listservs known to contain the addresses of FGCS. Students were given the opportunity to

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consent to participate and to answer questions on a short survey. Some students consented to follow-up interviews with the research team, using a semi-structured interview protocol (see Appendix), and were given $10 gift cards as an incentive to participate.

To explore the research questions in the present study, two members of the original research team from CU Boulder re-analyzed the interviews conducted with FG engineering students from their institution (n = 11). The authors used qualitative content analysis methodology to interpret the content of text data and address research questions through a categorization process (Mayring, 2000). The authors reread the interview transcripts, collaboratively developed an initial codebook using Dedoose qualitative data analysis software, coded a sample transcript individually, and used this sample to discuss and modify the codebook (Guest et al., 2012). Individually, the authors coded half of the transcripts as first coder and then reviewed the other half of the transcripts as second coder, noting questions or areas of discrepancy to discuss together. The authors then identified and exported a core set of excerpts associated with codes of most relevance to the research questions and examined these excerpts individually to create groupings of themes (Guest et al., 2012). To determine the final themes, the authors discussed the individual categories, in alignment with the research questions. As part of an asset-based research orientation, the authors have valued the richness of students' voices and have included their direct words to convey their experiences as much as possible in the following results.

Research Context

This study was conducted at the University of Colorado Boulder, a predominantly White, large, public research university. The engineering college is approximately 22% of the student body and the second largest college at the university. FGCS are approximately 16% of the engineering student population (University of Colorado Boulder Institutional Research, 2021).

CU Boulder's University Libraries are one aspect of interviewees' rich information landscape and student life, so we provide brief context of our library spaces, collections, and personnel. The Libraries include vast electronic and physical collections across five locations, including an Engineering, Math and Physics Branch Library. Approximately 150 information professionals work in University Libraries, including the authors of this study. One is a liaison librarian working with practitioner-focused education and social science disciplines, and the other is a liaison librarian working with the College of Engineering and Applied Sciences. Robust IL instruction is provided for undergraduate engineering research

programs. IL instruction for engineering design courses is limited and dependent on instructor requests. At the time the interview data was collected, several community building and innovative events were held in various library locations where engineering students studied.

Findings

The findings are organized by the research questions. The first question centers on FGCS identities, strengths, and the engineering discipline; subsections explore students' motivations, intersecting and multiple identity categories as they relate to the engineering discipline, and the ways in which students form social communities as part of their information landscapes. Findings for the second research question focus on students' information practices and include subsections on the social nature of information practices, students' evaluation strategies, and the ways in which higher education functions as an information landscape which FGCS must navigate.

RQ1: How do the intersecting identities of FGCS relate to the strengths students bring to their practice of engineering?

Connecting IL instruction to student passions is important, as research has shown that most students' motivation to conduct research is dependent, in part, on the topic being researched (Cahoy & Schroeder, 2012; Jacobson & Xu, 2004; Klentzin, 2010; Nichols Hess, 2015). In addition, it is important for librarians to understand students' lived experiences and strengths as they relate to students' information practices and as part of being student ready (Ilett, 2019b; White, 2016). Thus, we explored interviewees' identities related to FGCS status, engineering, and additional social identities as they relate to their interest in the project-based discipline of engineering.

Student Motivations

Both engineering and FGCS identities were salient to most interviewees, and exploration of these identities highlighted their motivations to obtain a college degree and to study engineering specifically. When interviewees spoke of their FGCS status, they described it as "having the ability to do what I want to do and make my own choices." Other interviewees discussed being forward-thinking and risk-taking, viewed their FGCS status as an honor, and considered it "evidence of what I'm doing to help my family out." For interviewees, college was something they pursued intentionally and had to spearhead on their own or

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something they pursued because they saw their parents "struggle and wish they had gone to college." These sentiments highlight how self-motivated interviewees were to attend college, an asset they brought to their educational experiences. Families played a role in motivating interviewees to attend college, such as prioritizing education, or wanting to support their families with the opportunities a college degree provides. In discussing their FGCS status and experience navigating higher education, family support was a clear asset for many interviewees. Several discussed the support they gained from siblings or cousins who started college around the same time. This echoes Rodriguez et al.'s (2019) finding that siblings can be motivational and supportive in attending college and studying engineering.

Interviewee strengths that motivated their study of engineering included their interests in math and science, their career goals, their desire to solve problems, and their values, such as wanting to impact humanity positively. The ways interviewees wanted to impact the world included making medical devices and solving environmental problems such as the Pacific garbage patch. Completing a first-year projects class cemented the desire to study engineering for one interviewee because they got to do a hands-on project that engaged their interests. The high paychecks engineers earn was never mentioned as a primary motivation, but knowing that an engineering career would also have financial benefits allowed interviewees to feel more confident in pursuing a costly degree and potentially high student loan debt. This demonstrates how cost and debt are factored into FGCS decision making about what and where to study. This pragmatism represents a future-thinking strength of FGCS.

Intersecting & Multiple Identities

Since higher education is most accessible to those with the most power in society, FGCS are more likely to be those with low socioeconomic status, in racial and ethnic minority groups, and immigrants or the children of immigrants. In addition to their engineering and FGCS identities, many of our interviewees had additional salient identities that intersected with their engineering and FGCS identities. The results below echo Rodriquez et al.'s (2019) finding that FGCS Latinas build their engineering identity "in relation to their other identities" (p. 18). Because of these multiple, intersecting identities and life experiences, FGCS have funds of knowledge to draw on to succeed in higher education and engineering. In addition, community can be built around these shared social identities, allowing students to connect with peers with similar lived experiences and build sources of social capital.

Although interviewees did not describe experiencing their intersecting identities separately, the findings below discuss these identities separately and note crossover between them.

Socioeconomic Status

Several interviewees described their family's financial situation, explaining that their families were not able to financially support their college education or that they did not want to burden their families. All interviewees described some kind of financial stress, and many described the stress of balancing school and work. Though financial limitations were a source of stress for interviewees, they also described funds of knowledge from growing up with limited financial means. For example, one interviewee discussed grocery shopping and meal planning on a budget with their parent during childhood and felt they had strong money management skills as a result that they brought to their college experience.

Many interviewees valued scholarships for the financial benefits, but one interviewee also described their engineering scholarship cohort as being a community and source of new friendships. This illustrates the ways in which relationships and social networks operate as social capital for FGCS. However, another interviewee explained how the time required to apply for multiple scholarships became an additional burden and source of stress. This is an example of a barrier higher education creates for FGCS and low socioeconomic status students. One interviewee stated, "I think that they forget about the people like me who don't have someone paying for college," illustrating the "left-behind" feeling FGCS with higher socioeconomic stress may experience. In addition to all these sources of financial stress and impacts, the lack of socioeconomic diversity at the institution may negatively impact students. One interviewee discussed how they believed the high cost to attend the institution negatively impacted the diversity of the student body.

Race and Ethnicity

Race and ethnicity were also salient identities for interviewees, especially in a predominantly White institution (PWI). The engineering college's efforts to support community belonging for racial and ethnic minority students created positive experiences for Black, Latina/o, Asian/Pacific Islander, and bi-racial interviewees. One interviewee in a living-learning community largely made up of engineering students of color felt they had a living environment where they were comfortable asking for help, while another found a sense of community in the Society for Hispanic Professional Engineers and the engineering college's diversity center that helped them feel at home at the institution. Thus, minoritized

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interviewees sought out communities of engineering students who shared similar racial identities to have a network of academic and professional support. Students' use of these resources and groups represents development of social capital as they navigate racialization within a PWI. If institutions were more student ready for racially and ethnically minoritized students, the burden on students to find and maintain such spaces for their well-being and survival at the institution may be lessened.

Interviewees described negative experiences on campus related to their racial and ethnic identities. One Asian/Pacific Islander interviewee expressed exhaustion at having to educate their peer on their perspective and experience. Another interviewee who identified as Hispanic/Latino described "aggressive notes" left on their bike while on campus, challenging their sense of belonging. Both of these interviewees also described culture shock when first experiencing the predominant Whiteness of the campus. Similarly, Verdín and Godwin (2018a) found an unwelcoming culture for FGCS Latinas in engineering. These experiences represent key areas where PWIs and workplaces have ongoing work to become student ready. The onus for these shifts must move from individuals to institutions.

Immigration Status

Several interviewees identified as immigrants to the United States or as the children of immigrants to the United States, including students with Deferred Action for Childhood Arrival (DACA) immigration status. Immigrant experiences may add layers of oppression and nuance to students' engineering experiences because DACA status can represent a barrier to pursuing certain engineering jobs as some require citizenship. Fortunately, one interviewee was affirmed in their engineering identity because a company in the aerospace and defense industry was willing to "pull strings" for them highlighting, "If I could show that I'm good enough ... there will be a company that would want me regardless of my status." This interviewee recognized their engineering knowledge and skills were valuable, in spite of the barriers government, industry, and higher education have created for DACA students. This interviewee demonstrated significant strengths in persisting towards their goals despite uncertainty and systemic obstacles. DACA status also intersects with financial barriers, as DACA students are unable to take out traditional student loans. Illustrating interviewees' feelings of uncertainty about future careers, housing, and safety, one interviewee described their DACA status as a "black curtain where you don't ... know what's on the other side." These experiences highlight the extra stress related to systemic barriers of citizenship and finances that students with immigrant identities may experience.

Gender

While women are not underrepresented in higher education, they are still underrepresented in engineering university programs (National Center for Education Statistics, 2019) and in the ranks of professional engineers (U.S. Bureau of Labor Statistics, 2021). Gender identity was particularly salient for one White interviewee. The percentage of women in her major, mechanical engineering, was low, and she recognized this large disparity but felt accepted and as though she had found strong communities in the department. For this student, a sense of belonging came from her job in the college's prototyping facility and through events, like dinners and tea parties, held by women faculty for women students. While this interviewee felt she was recognized for her engineering knowledge and skills, she noted that women students may have to prove themselves more than their male peers. With regards to her FGCS identity, this student stated, "I feel like that's more of a hurdle than being female." Another interviewee discussed the value of the campus Women in Computing group. Rodriguez et al. (2019) also reported FGCS women describing programs for women in engineering as being integral to their success; thus, FGCS need support for all their identities, including their gender identity, in engineering spaces. FGCS students who are gender minorities in engineering are making use of assets such as persistence, belief, and their own sense of agency within their college experience.

RQ1a: How do students' identities inform social communities?

As discussed in the previous section, the FGCS interviewees became involved with communities that were largely related to engineering and often connected to another identity, such as race/ethnicity, gender, or scholarship status. These communities represent sources of social capital for FGCS in engineering, vital for highly collaborative engineering curricula, as engineering students form study groups and work on group projects with their peers. Peers are also a source of support and commiseration for getting through the rigors of the engineering program and the stresses of college life. For example, one interviewee stated, "So most of my life is around engineering people just because like it's—it's a positive thing for classes to collaborate together. And also, just like by the nature of the people I'm around. Those are the people I grow close to." The extracurricular groups interviewees joined also allowed them to further explore their engineering passions via field trips, speakers, and extracurricular projects. Engineering clubs were a valuable place to meet more senior students who were great sources of information, as one interviewee described:

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In our coffee hours you get the chance to ... talk to the senior engineers and be like, "Oh, did you take this class, or did you have this professor?" ... You know it's really great to get advice from them and, you know, talk about projects. ... And then you have people who have internships ... and "If you want to ... work for this company ... let me know and I can give you a word in."

These examples highlight the value of engineering groups as sources of social capital and information, illustrated by one interviewee saying, "Your network grows more if you are around people who are interested in the same things that you're interested in—and that's another ... opportunity to learn things from other people."

Communities based in engineering, where social capital and information about engineering academics and professional development could be shared, were widely discussed by interviewees, but communities based on FGCS status were seen less frequently in the findings. The FGCS groups that interviewees described were during their high school time, when they were navigating applications for colleges and scholarships. This lack of FGCS identity-based communities in college was just fine with several interviewees who felt their FGCS identity became less salient once the process of getting into college was behind them. Some interviewees, however, would have been interested in such a group to help with navigating being in college. This finding suggests that FGCS engineering students may benefit from FGCS identity-based campus groups to access social capital and information related to "college knowledge," just as they do for "engineering knowledge" through campus engineering groups.

RQ2: How do first generation engineering students describe their information practices?

To provide context for FG engineering students' information practices, the types of assignments interviewees recounted were design-based projects for first-year projects or upper division courses. These collaborative assignments included designing and coding a heart-rate-based watch to wake up sleepers after a power nap, building a drill-powered tricycle, designing and building a motorcycle, and using computer programming skills in a simulation to prevent a bomb from exploding. The research team asked all students to describe the practices they use for navigating their design-based information needs, yielding the following themes. The IL strategies described by interviewees are probably gained from funds of knowledge from their lived experiences, K-12 education, and the engineering curricula they had encountered as no interviewees described an experience of learning research strategies from a librarian.

Information is Social

Consistent with engineering literature, the authors found that FG engineering student interviewees gravitated strongly toward using people and their social networks as sources of information. This practice represents a significant strength given the information practices among professional engineers (Allard et al., 2009; du Preez, 2015; Hertzum & Pejtersen, 2000; Jones, 2017; Saleh, 2012). Interviewees reported asking others for help determining project parameters and technical specifications and seeking general advice from experienced engineers. As one interviewee described, "Before we even decided what our project was, we had to do a lot of research, and it wasn't just like Googling stuff. It was also asking professors and students … if we were gonna have equipment accessible to us to actually complete this and if our idea was, like, manageable for the time we had." In discussing how these practices differed from other academic disciplines that rely more heavily on textual sources, a student explained, "If I had a question I would ask my TAs, my professors, or the machine shop foreman just because they had more hands-on knowledge and it was a more specific issue. So that's the kind of thing where, like, personal expertise comes in handy more than just reference books, I think. Though there are some great [text sources], like *Machinery's Handbook*." Another interviewee also described how professors and tutors suggested helpful sources, thus acting as mediators to information.

The authors noted a shift between two types of academic IL contexts among FG engineering student interviewees that both involved the social flow of information. In the first context, students were required to look up specific answers or problem-solving strategies for lower division math or science courses or for computer coding. Within this first type, interviewees still placed a high value on social networks and peer support. This social support seemed to be crucial for many interviewees in getting through challenging lower division courses and persisting in the major and illustrates students' use of social information practices as an asset.

The second type of IL context related to design-based work that often had no one correct answer and required guidance from more experienced engineers or a deeper understanding of the engineering information landscape. An interviewee working on a solar energy project demonstrated the social flow of information in this context when sharing their experience consulting with another professor on campus saying, "He's letting us borrow some equipment, giving us advice. So, I think that also, aside from the internet, that's a really good

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resource, just people." Continuing on, they emphasized the value of social networks that helped students connect with researchers or other experts.

Information Evaluation Strategies

Interviewees reported they were much more likely to use the internet to find information quickly, even if it was less thorough than other sources. This finding aligns with previous engineering literature that has found similar behavior among both students and practicing engineers (King, 1994; Lamont et al., 2020; Mercer et al., 2019; Rosenbloom & Wolek, 1967; Saleh & Large, 2011; Whitmire, 2002). These practices are strengths in that satisficing and recognizing the amount of effort needed for a given task align with existing engineering information practices (Fosmire, 2014).

Interviewees employed several strengths when evaluating information, such as focusing on pragmatics, direct experience, precedent, and trust. Specific strategies included gauging the effectiveness of coding videos by asking "does it work?" An interviewee explained: "A lot of times a YouTube video will be much better because they run it and you can see that it runs, meaning, you know … no errors. Versus Stack Overflow, someone will post 'yeah, it looks like this' ... so when you copy paste [and] that doesn't work, and you don't know what the problem is." In another example of this evaluation strategy, an interviewee discussed determining the angle of a motorcycle fork from an existing product: "It sounds bad, but ... we don't really care where they got their information because they've proved that it works in like the series of their motorcycles that have worked for years." These examples demonstrate discipline-specific practices where credibility is frequently determined by direct experience and precedent, which is also seen in the literature (Mercer et al., 2019; Tenopir & King, 2004). The authors also noted interviewees trusted people in their networks as credible because of their relationships and experiences working with those people, whereby people were both sources of information and a type of evaluation criteria.

Interviewees also described sifting or filtering as an evaluation strategy. This strategy involved skimming a list of search results and determining what was relevant or of interest, a kind of on-the-fly evaluation or selection process. When looking for specific information, it seems interviewees had a fairly clear vision of the information landscape and what they were looking for, and this familiarity guided their searching and sifting, as opposed to the more open-ended searching required in some phases of design-based projects.

Higher Education as an IL Landscape

Higher education represented an important IL landscape for FG engineering college students. To navigate the landscape, interviewees used practices such as accessing information and support through peer, family, and campus staff networks to gain an understanding of higher education processes and to advocate for themselves. When students intentionally engage these networks, they demonstrate strengths such as self-awareness and metacognition, and the use of social capital (Franklin et al., 2018; Martin et al., 2013, 2014). Several interviewees described how these networks often began in high school with programs or counselors that helped them prepare and apply for college, serving as both conduits for college-going information and as motivation and social support.

Related to help-seeking, four interviewees discussed the vulnerability in admitting one does not know something and asking for aid. One explained this through the lens of a FGCS experience: "when we don't find the resources or don't know where to look for them, it makes us anxious, and I do know that the biggest drop out rate is for first-generation so I think just making the resources, not more accessible because they are accessible, but just more *known* would help." Five additional interviewees talked about relying on their social networks for help navigating the university. One described how their engineering advisor and a degree program flow chart were crucial sources of information to stay on track for four-year graduation while needing to repeat lower-level math and physics courses that did not go well in the first year. An interviewee in their first year valued their advisor for understanding course acronyms and helping them register for classes. These experiences illustrated interviewee strengths and courage in asking for help as they navigated uncertainty.

Some interviewees described how emotional and social support were closely tied to navigating college information, particularly in scholarship programs dedicated to FGCS. Another interviewee viewed the campus mental health counselors as a source of emotional support for first generation college students who experienced stress and other negative emotions while trying to navigate the bureaucracy of a large university. Reflecting on peers who had left the university, one explained, "I think part of that is [being] just too locked in their rooms ... you know, if you don't have a community to be with you, in classes, stuff like that, it's hard to, it's very easy to lose motivation, lose focus, lose your goals," highlighting the value of community for this interviewee's persistence.

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Implications: IL for Project-Based Design

As is found in higher education broadly, academic libraries participate in larger systems that create barriers for FGCS. Librarians and educators may not always consider higher education as an information landscape worthy of IL instruction in comparison to support for academic work. Yet, academic libraries can help FGCS develop multiple forms of IL as they navigate college as an information landscape.

Librarians and educators can link students' funds of knowledge or strengths to IL via design-based projects. FG engineering students are often professionally motivated to solve problems, use math and science, and work with their hands. Our interviews illustrate how students found hands-on, team-based design projects to be deeply engaging learning experiences. Within team-based learning, collaborative IL is an important technical proficiency and is mediated through social relationships. By integrating IL instruction into hands-on group learning projects, students can continue to develop information practices that include embodied, text-based, and collaborative information sharing. In other words, students can develop IL skills which are integrated into the design process and will be transferable to their professional goals. As Folk (2018) noted, students who pursue topics tied to their funds of knowledge tend to display higher intrinsic motivation. Thus, IL connected to design projects will motivate students' IL learning. Librarians can seek out collaborations with design-based courses, from first-year design experiences to senior capstone projects, to collaboratively integrate IL learning into the design process.

Students' existing practices can be the foundation for additional conversations that librarians can engage in with students. For example, librarians and educators can build on students' funds of knowledge by discussing information evaluation strategies students use, such as the "does it work?" idea and trust in what is proven. Classroom discussions on knowledge management practices can also build on students funds of knowledge related to how they share information within their collaborations and networks.

Librarians and educators can support FGCS in building social capital by encouraging students to thoughtfully seek out people as an information source and as a way to vet information, as this is a professionally relevant information practice. Interviewees used a range of criteria to evaluate information sources, and IL instruction can build on these strategies by encouraging students to collaboratively develop principles for source evaluation (Ilett, 2019b). This instruction practice would allow them to critically contemplate their own practices, consider the practices of peers, and incorporate

recommendations from experts such as professional engineers, engineering professors, and librarians. Students can also deepen social networks among their peers by working in groups. Through group and team-based projects, students can learn from each other's information practices to incorporate others' knowledge into their own knowledge base, where the group collectively specifies what content is appropriate for the context (Allard et al., 2009; du Preez, 2015; Hertzum & Pejtersen, 2000; Jones, 2017; Lloyd, 2010).

Within engineering specifically, FGCS have valuable funds of knowledge that position them to succeed in the engineering profession. These funds of knowledge may include the ability to design amidst scarcity and an understanding of social and information practices within specific community contexts (Lloyd, 2010; Smith & Lucena, 2016a). Hands-on-learning design projects can include limited budgets and the need to seek out low-cost and locally available resources. FGCS from minoritized racial and ethnic and immigrant communities know the cultures of their communities, are often aware of community needs, and can design solutions that work within and complement those cultures. As highlighted by Smith and Lucena's (2015) research, FGCS are often highly successful in collaboratively performing engineering work that integrates their professional engineering skills and the experiences of technicians, which may reflect students' lived experiences of both working class families and professional-class engineering environments. FGCS' funds of knowledge can also be applied to solve problems that span high-tech engineering contexts, such as the interviewee who interned with an aerospace and defense company.

Limitations

The data for this article were gathered following an asset-based framework via semi-structured interviews with a small sample size (n=11). While generalizability is not appropriate for qualitative findings, this study aspires to transferability of the findings to similar contexts (Miller, 2008). Additional limitations include self-selection bias, where students may have self-selected to complete the initial survey and opt-in for follow-up interviews based on the salience of a FGCS identity to them, or due to particularly positive or negative experiences on campus (Olsen, 2008). Interviews were conducted in library study rooms, which may also have influenced students' responses through social desirability bias, in particular to questions about library use (Spector, 2004).

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Conclusion

Higher education is, historically and currently, less accessible to lower-socioeconomic communities, members of minoritized racial and ethnic groups, and immigrant communities, so it is not surprising that students with these identities are more likely to be FGCS. Placed in context, the findings are part of the larger history of engineering and higher education that evolved from apprenticeships and learning on the job towards expecting students to self-fund their education, complete internships, and earn a college degree without a guarantee of a related job after college (Smith & Lucena, 2016a).

The findings from this research demonstrate that FGCS students have nuanced and powerful motivations for choosing a design-based professional program such as engineering and bring with them strengths from their lived experiences and social identities that contribute to their academic and social wellbeing on campus. Predominantly White campuses also maintain persistent barriers to FGCS success, underscoring the importance of communities that support FGCS academically and holistically. These social networks are a significant strength within students' information practices, where information flows to assist students completing design-based assignments as well as navigating college life. These interviews demonstrate a range of evaluation strategies students employ, and opportunities for librarians and educators to build on these strengths when working with FGCS students.

As researcher-practitioners, the authors valued listening deeply to FGCS in engineering. Interviewees allowed us to understand more about the information practices that they bring with them to higher education, framed through the lens of funds of knowledge, complementing and connecting to what students already know rather than assuming deficits that librarians and educators need to "fill." Looking more deeply into a specific disciplinary context that engages in design-based and collaborative IL is especially valuable in considering how information practices are, or are not, able to transfer contexts and how students apply these IL strategies to navigate coursework and campus systems While this study focused on first generation college students in engineering, the findings may be relevant to librarians and educators working in a range of disciplinary contexts that share a design, project-based, or practitioner focus.

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Appendix: Experiences of First-Generation College Students in Colorado Academic Libraries Interview Guide

The following questions constitute the interview guide used by researchers at CU Boulder for the follow-up interview. These interviews were designed to be semi-structured and open-ended, and the interviewer may have added additional questions or follow-up questions, as necessary. These questions should therefore be understood as a framework rather than a script.

- How did you decide to come to this institution?
- What was the transition from high school to college like for you? What types of resources did you have at your high school?
- How do you define being a "first generation college student"? What does that mean for you?
- What barriers have you encountered?
- Who do you turn to for support when you encounter barriers?
- What has been helpful to you on campus?
- What skills or knowledge from high school (or earlier) are you able to use to be successful in college?
- What skills or knowledge from home or your community are you able to use to be successful in college?
- Who do you turn to for assistance with academic assignments and projects?
- Please tell us about a research assignment you had recently. Has your approach changed from your first assignment? What skills, tools, or resources do you find yourself using now?
- Have you ever gotten help/talked to a librarian? What was your experience?
- How often and in what ways do you use the libraries?
- How do you see the library / describe the library? Has your perception changed over the course of your time in college?
- Have you encountered any barriers to using the library?
- Did you receive any library instruction? How did it change your use/perception of the library?
- How do you use the library most frequently (i.e., study space, research help, databases)?
- How could your experience at the library be improved?
- How does the academic library compare to other libraries you have used (ex. high school, public)?