2023-10-10

Workplace Spaces As Learning Spaces – Engineering Students' Experiences With Co-Op

Maartje VAN DEN BOGAARD
University of Texas at El Paso, United States of America, mvdbogaard@utep.edu

Johannes STROBEL
University of Texas at El Paso, United States of America, jmstrobel@utep.edu

WORKPLACE SPACES AS LEARNING SPACES - ENGINEERING STUDENTS' EXPERIENCES WITH THE CO-OP

M.E.D. Van den Bogaard [1]
University of Texas at El Paso
El Paso TX, USA
ORCID 0000-0002-2267-3674

J.M.J. Strobel
University of Texas at El Paso
El Paso TX, USA
ORCID 0000-0002-2124-1116

Conference Key Areas: *Engagement with Industry and Innovation, Curriculum Development*
Keywords: *Co-op, Workplace Learning, Engineering.*

ABSTRACT

Many authentic learning environments in formal schooling contexts mimic elements of authentic engineering environments, yet do not afford students to experience the full complexity of a real work environment. Workplace learning is a powerful way for students to close these gaps. In this exploratory study we interviewed 11 students about their experiences in a co-op program in a Midwestern research university in the USA pre-COVID. Our qualitative study was guided by the three dimensions of learning by Illeris: personal, cognitive and social learning. We added the perspective of epistemic learning. Our preliminary findings include a variance of workplace experiences, the tensions between execution of specific tasks and the exploration and ideation of new solutions. In addition, our findings indicate that workplace engineering was demystified as issues students shared were very specific context related and not career choice related. Students also report they learned about relationship building with people from all levels of the organization, the importance of soft skills, and awareness of evaluation as a tool for reflection on the projects and their own professional development.

[1] *Corresponding Author*
M.E.D. Van den Bogaard
mvdbogaard@utep.edu

1 INTRODUCTION

Many innovations in engineering education focus on implementing learning environments that are authentic and encourage students to actively engage with knowledge and practice (Strobel et al. 2013). Authentic learning environments in formal schooling contexts mimic elements of an authentic engineering environment, yet do not afford students to experience the full complexity of a real work environment (Barab and Duffy 2012). Workplace learning is a powerful way for students to close these gaps and it allows for personal and professional development (Sawchuck 2011). Some engineering programs require students to do work placements where they work on real engineering assignments, collaborate with colleagues, and get enculturated into workplace culture. There has been very little research into the wider learning experiences and outcomes in the workplace, specifically in co-op learning in engineering. Co-op is defined as a unique form of experiential learning (Kolb 1984) integrating classroom study with paid, planned and supervised work experience in the private or public sector (Garavan and Murphy 2001). In this study, we employed and extended Illeris' (2003) theory of human learning as a theoretical framework as we are interested in mapping the personal, cognitive, social and epistemic learning experiences students have in their co-ops and their perceived learning outcomes. Our research question is: What are the learning experiences of students in co-op programs and how can they be mapped to personal, cognitive, social learning and epistemic dimensions?

1.1 Literature Review

The integration of workplace learning in engineering education has become an increasingly important topic in recent years (Dehing, Jochems, and Baartman 2013). The benefits of workplace learning for engineering students include exposure to practical applications of engineering concepts, development of professional skills, and enhanced employability (Zehr and Korte 2020). Several studies have explored the effectiveness of workplace learning in engineering education. A study by Jackson (2013) found that students who participated in work-integrated learning (WIL) had a better understanding of the relevance and application of theoretical concepts in the workplace. Similarly, a study by (Sangwan and Singh 2022) showed that engineering students who participated in internships had better problem-solving skills and were better prepared for the workforce. While the literature suggests that workplace learning can provide significant benefits for engineering students, including improved understanding of theoretical concepts, development of professional skills, and increased employability, the literature does lack a mapping of the broader and comprehensive space of learning experiences of students.

1.2 Theoretical Framework

To ground this study, we chose as a starting point Illeris' (2003) theory of learning which is based on three interrelated dimensions of learning: cognitive, emotional, and social. The cognitive dimension involves acquiring new knowledge, the application of theoretical knowledge, problem solving and technical skill development (McNeill et al. 2016; Perkins and Salomon 2012). The emotional / personal dimension involves self-awareness, self-efficacy (Makki et al. 2015), motivation (Paloniemi 2006) and personal growth elements such as personal development and resilience (Sheppard et al. 2008). The social learning dimension involves collaboration (Fuller et al. 2005), teamwork (Bhavnani, Sushil, and Aldridge 2000), mentorship and professional networking (Wong et al. 2018). We extended the threedimensional model and added *epistemic learning* as a fourth dimension. The epistemic learning dimension draws from existing work on epistemic framing (Shaffer 2004; Arastoopour et al 2016) and involves the learning of what it means to be doing engineering work, engineering practices, technologies, and workplace cultures.

2 METHODOLOGICAL FRAMEWORK

For this exploratory study, we used thematic analysis (Braun and Clarke 2012) as our methodological framework which involves identifying, analysing, and interpreting patterns and themes within data. This approach is commonly used in social sciences where researchers aim to gain an in-depth understanding of a particular phenomenon.

2.1 Population and data collection

We conducted a brief recruitment survey among all undergraduate engineering students within a research-intensive Midwestern university within the USA to determine their level of experience with co-op settings pre-COVID. All students participating in this study were part of the co-op program which included the following features: after one semester study within the university, students worked for the second semester at an industry workplace in a paid and mentored internship. The yearly structure continued for the entirety of their undergraduate program. Students in the co-op program usually worked in the same workplace throughout their undergraduate career, yet some students were placed or chose different workplaces. Students in the co-op options tended to graduate slightly later than their counterparts who studied full-time for their undergraduate studies yet had immediate work placement after graduation. From the students responding we chose 11 students who varied in their experience with the co-op program for an in-depth semi-structured interview which lasted on average 45 minutes. The study included first-year to senior students (age 18-25).

2.2 Analysis

Our process of thematic analysis involved the following stages (see Guest, MacQueen, and Namey 2011 for details): (1) Familiarization with the data: We read and familiarized ourselves with the raw data of the interview (transcript and audio). (2) Generating initial codes: We identified words, phrases, or sections of text which were relevant to the research question and created initial codes to categorize the data. (3) Developing themes: We identified patterns and connections between the codes and grouped them into broader themes or categories. (4) Reviewing and refining themes: We reviewed and refined the themes, ensuring that they accurately reflect the data and are consistent with the research question. (5) Defining and naming themes: We defined each theme and gave it a name that accurately represents its content and meaning. (6) Writing the analysis: We wrote up the analysis, providing examples from the data to illustrate each theme and highlighting the key findings. The quality of the qualitative analysis was evaluated according to Tracy (2010) by the collaborative development of the coding framework, verification of codes and their application and sample verification processes.

3 RESULTS AND DISCUSSION

3.1 Cognitive learning dimension

Within the cognitive learning dimension, we identified three separate areas of cognitive learning: Technical Skill Development, Application of Theoretical Knowledge and Problem Solving and Critical Thinking. Technical Skills Development pertains to learning and refining technical skills through hands-on experience with tools. Students mentioned how they honed their skills with mostly software in their co-ops. They report that the tool they used most often is Excel, and many students report they learned to use the Visual Basic functionality as it allowed them to do many things they would do in MATLAB in their university coursework. One student mentioned: "*There's an obsession with MATLAB at this institution. We don't use MATLAB. We use Excel.*" It was surprising for us to see that their reported use of mathematics and software tools supporting mathematical analysis was on a lower level than expected, yet this finding supports results from a previous study on the very limited use of calculus or advanced mathematics even in engineering curricula (Faulkner et al. 2020). One student mentioned explicitly that the clients they worked for all had different software packages, and learning how to work with all of these was challenging, although many packages are alike pointing to flexibility as a core professional skill (Siller et al. 2009). The Application of Theoretical Knowledge theme signals that the application of theoretical knowledge goes both ways: students can often use theoretical notions in their co-op, yet they also bring knowledge of practice to their advanced courses and are able to ask questions in class that go beyond the steady state situations that are often discussed in class which reinforces earlier findings (Eraut 2012; Brahimi et al. 2013). In some cases, students report that their co-ops informed their choice of advanced courses as they realized they missed certain knowledge while they were at their co-ops: "*My co-op experience basically kind of determined what classes I was going to take.*" This finding hasn't been previously reported in the literature.

The cognitive dimension that was mentioned most often pertains to Problem Solving and Critical Thinking. We identified two areas where Problem Solving and Critical Thinking were pertinent: Defining Constraints and Solutions, and Information Finding. Most students found that the scope and constraints of their co-op projects were ill-defined and that a major part of their project was to define their own constraints and specs confirming previous workplace research studies (Jonassen, Strobel, and Lee 2006). Students also found that the social dimension of Collaboration and Teamwork was essential for this part of problem solving as described by prior studies (Trevelyan 2019; Mora et al. 2020). Information Finding proved to be a challenge for many students. They found that a lot of relevant knowledge is tacit knowledge of colleagues and that it is paramount to talk to colleagues in all layers of the organization to gather relevant information to understand the problem within the context, to understand the constraints of their project, and to understand how any solution they come up with needs to fit in the overall processes and workflows of the organization - which mirrors findings from Paloniemi (2006). Students recognized that Information Finding has a social dimension as well as a cognitive one, which supports previous research on engineering students information behavior while in college (Leckie and Fullerton 1999). Students report that overall problem solving is what challenged them cognitively, they often use the term themselves too. It pertains to finding solutions for things they do not yet know, for trial and error, for struggling to find expertise in the organization, and identifying which concepts they learned in class are relevant for the problem at hand as similarly shown by Dixon, Raymond, and Brown (2012).

3.2 Personal learning dimension

Within the Personal Learning dimension we identified three areas of learning: Self Awareness, Self-Efficacy and Personal Growth. Self-Awareness pertains to understanding one's own strengths and weaknesses through self-reflection. Students indicated different areas of strength in the following areas (the list is a combination of all the areas mentioned): communication skills, work ethic, humbleness towards their own competence and their non-engineer colleagues, importance of knowing how they work best, ability to adapt to change, ability to have realistic ideas on how much time certain tasks take, ability to accept criticism, or an ability to communicate about issues in non-threatening ways. While students used language such as "strength", none of the students used the term "weakness". Students rather referred to challenges. Previous research on students' perceptions of readiness mention students explicitly using the term "weakness" (Martin et al. 2005) with a noticable difference that the population of the study by Martin et al. are graduates of engineering programs who had no reported workplace experience. The lack of mentioning weaknesses could also relate to a deeper concept of professional shame which is nascent in research (Secules et al. 2021)

All co-op students are asked to write a reflection report on their project and most students found it helpful as it helped them be aware of all the different activities they engaged in during the co-op which reaffirms existing research on workplace reflection (Barthakur 2022). Self-Efficacy is mentioned in relation to having to learn new skills and tools on the job through independent study, often under time pressure. It is notable that students discuss their self-efficacy on a micro and very specific technical level and not in the context of for example career self-efficacy (see Makki et al. 2015 for a framework on career self-efficacy). Students mention that co-ops have steep learning curves, as there is not much time to deliver on the projects. Semesters are 16 weeks long, and the projects are increasingly challenging. One student mentioned: "*I learned the basics at school, and then I learned some actual language by myself doing work co-op.*"

Students can commit to doing multiple co-ops with the same company and the company tends to start with easier projects, to have students work on highly complex projects in their later placements. Students appreciate this as it supports their growth. One student mentioned they started with a supply chain project and asked for a manufacturing project in the next placement, as they realized supply chain and manufacturing were strongly related, yet had very different logic to them. The Professional Growth theme reflects experiences ranging from developing better time management skills to stepping up to the plate and taking on full responsibility for their contributions, to the realisation that working is about learning new things. Students report they feel more confident after every placement and generally feel prepared to enter the labor market after their studies, because they know what to expect and know better than most classmates what they enjoy doing. In terms of self-efficacy, students did not express doubts about career choice or if they are able to overall work as an engineer. The concerns shared were more mundane and grounded in specific work context. This finding corroborates existing research that shows that workplace learning is a tool to provide confidence and demystify the profession (McEwen and Trede 2014).

3.3 Social learning dimension

In the Social Learning dimension we found experiences reflecting many elements of collaboration and teamwork. All students mentioned that collaboration, communication and problem solving are essential for finishing co-ops successfully. The importance of collaboration and teamwork emerged from all interviews and all students mentioned experiences in their social environment that had been important for progress in their projects. Projects could not be finished without input from colleagues at all stages of the project affirming previous conceptualizations of workplace learning as a form of participatory practices (Billett 2001, 2004). This partially has to do with the fact that the students found that much knowledge of importance is '*human knowledge*'. One student mentioned "*I think the model for working alone has passed. It's more a team-based environment … where [my] work is semi-autonomous.*" Within the overarching theme of Collaboration we found three sub themes: Collaboration with Different Stakeholders, Communication, and Joint Decision Making. Collaboration with Different Stakeholders reflects the importance of collaborating with operators on the factory floor, for example, the accountants, marketing professionals, and engineers from other companies who have knowledge and understanding that is paramount to fully understanding issues and understanding the overarching workflow of which the students' project is a small part (McMartin and McGourty 1999). One student mentioned that there is also a generational aspect to this: older engineers sometimes have different expectations of professional behavior and communication. Other students found that operators, accountants and marketing professionals bring unique perspectives to how problems are defined and what solutions are acceptable. One student who worked for a producer of consumer products was surprised to find how important the input of marketing was in manufacturing processes of packaging (Darling and Dannels 2003). Communication emerged as an important theme. Students mentioned the importance of asking questions and asking for input, open office spaces, open door policies and ease of communication through social media, yet also how busy some people are and that they are not always available when you need them. A third theme was Joint Decision Making. Many students experienced that important decisions were often made during team meetings where they discussed their work, or in joint decision making in meetings with their supervisors (see Halvorsen and Sarangi 2015 for different roles during team decision processes). Students were asked about any conflicts they may have encountered. Students all mentioned that in most cases, conflicts pertained to different ideas on solutions, and were usually easy to solve as everyone had an interest in solving the issue. Only a few students mentioned the importance of professional networking and mentoring. One student mentioned it in the context of understanding the importance of forging relationships with colleagues in all areas of the organisation where they work, another student mentioned they ran into a manager at a tailgating event and they were asked to connect when they were about to graduate as the manager would love *'to work something out'* with regards to future employment (see Dehing, Jochems, and Baartman 2013 who describe the development of relationship building).

3.4 Epistemic learning dimensions

Epistemic learning experiences pertain to students gaining an understanding of what it means to be doing engineering work and work in engineering contexts. As one student mentioned: "*Just having experience in general is a good thing. Because not only does it teach you how to be an engineer, it teaches you how to work* *professionally in the environment. That's not just with my company, that's with every company.*" We identified two themes: Real-world Application and Industry Exposure. Students experienced the Real-World Application of what they learned in their classes, yet were able to position their classroom learning in a bigger picture. One student said: "*[In] classrooms you're learning steady states, quasi-steady states. In the real world you're adding the safety component to it. … Also cash constraints … impose on your system and there's the people side of things. You have to learn how you adapt how that works.*" Findings of this dimension are corroborated by previous research which indicates the complexity and intricateness of workplace engineering problems (Strobel and Pan 2011). Another student shared that their project was decided on by the accountant, who established that the company was not holding up their service level agreement with a customer, which cost both parties a lot of money on a daily basis a dimension the student did not consider as part of the job before participating in the co-op experience. Students observe that many skills and formulas get meaning when they are using them to solve a real-world problem together with professionals in their co-op environment: "*That's when stuff really starts sticking for me, when I can actually kind of find the situation where I can apply it. Or it dawns on me, oh, okay, so that's why the senior engineer wanted to do it this way, is because this and this reason.*" Industry Exposure encompasses several sub themes: Workplace Culture, Professional Attitude and Problem-Solving. Students report the workplace cultures they encountered were very different from what they had expected, especially for students who did not have any engineers in their environment before they enrolled in their engineering programs (see Liu et al.'s 2020 conceptualization of this research space).

Students had expected the workplace to be rigid, individualized and that it would entail a lot of work on the factory floor. Instead students encountered team-oriented work environments that were focused on helping each other, valuing ideas and input and working with non-engineers as the norm which mirror what Darling and Dannels (2003) described as the oral nature of engineering workplace culture. Students observed that in such an environment, success is determined by their ability to solve problems, communicate effectively and their own enthusiasm and initiative to collaborate with colleagues and take charge: "*At work, the thing that's going to prevent you from solving a problem is your lack of initiative.*" To take initiative, it was important for the students to develop a Professional Attitude which students denote adapting to how colleagues communicate, dress and value each others' contributions (see Scanlon 2011 for a larger discussion of 'becoming a professional'). Professional communication was described as not using slang, learning to be precise in formulating thoughts and requests, and phrasing feedback in open-ended questions. Problem-solving in the context of epistemic learning has a different flavor than problem-solving as cognitive learning: in epistemic learning it is about reflecting on the bigger picture of problem solving and seeing it as something that is interconnected with overarching processes, that affects the organization on different levels and as an iterative practice and learning process - a finding of this study which has been addressed in existing literature on co-op or workplace learning in engineering.

4 LIMITATIONS AND FUTURE RESEARCH

The study is situated in the context of one Midwestern university in the US, which runs a specific version of a co-op program. Results from this study are impacted and are limited by the idiosyncratic program and implementation context within the university where the data have been collected. In addition, the study analyzed interviews collected from 11 students and is exploratory by nature. Interviews with different co-op programs and students at other institutes of higher education would enrich our dataset and could contribute to a wider and nuanced study of the phenomenon of workplace learning. Further research, particularly confirmatory survey research would be beneficial to study the extent of the existing dimensions among a larger body of students.

5 CONCLUSIONS AND RECOMMENDATIONS FOR PRACTICE

The research question that informed this study is: What are the learning experiences of students in co-op programs and how can they be mapped to personal, cognitive, social learning and epistemic dimensions? We found rich insights about students' learning experiences in the co-op program, where the dimensions of learning identified by Illeris (2003) showed up interconnectedly. Students shared that the social dimension, especially the communication, is essential for working in practice successfully. They also recognized that the social dimension is strongly connected with cognitive dimensions of work: setting constraints and specs for solutions. Students shared that they were surprised to find that working in engineering is a social experience, as many people provide important input for projects and that essential information is often only available as human knowledge. Students reported that they found the co-op experiences challenging in the sense that they often did not yet have the relevant knowledge, they had to identify which concepts they learned in their coursework were relevant, and they had to apply something of which they had learned only the basics. Applying basic knowledge to a real problem that exists in a context that is more complex than most examples discussed in class brings a whole new dimension to learning. In general, the students felt more confident about their ability to be successful once they enter the labor market, as they learned about workplace culture and what it takes to be a professional among professionals.

What we found striking is how little theoretical knowledge students seem to use once they are in a work environment. It is possible that students may not be aware of how much knowledge they actually apply. One student mentioned that the most important contribution of their professors is that they teach how to look at problems. Still we believe it is paramount to understand what elements of the curriculum are more and less strongly connected with professional practice and find a balance between workplace preparation and teaching the bigger concepts that are of importance to connect the dots between mathematics, science and engineering.

Overall we conclude that co-ops are rich learning environments in which dimensions of learning as identified by Illeris and extended by the epistemic dimension are present and strongly connected.

6 ACKNOWLEDGEMENT

We would like to thank dr. Rui (Celia) Pan for data collection.

7 REFERENCES

Arastoopour Irgens, Golnaz, David Williamson Shaffer, Zachari Swiecki, A. R. Ruis, and Naomi C. Chesler. "Teaching and assessing engineering design thinking with virtual internships and epistemic network analysis." *International Journal of Engineering Education* (2015).

Barab, Sasha A., and Thomas Duffy. "From practice fields to communities of practice." In Theoretical foundations of learning environments, pp. 29-65. Routledge, 2012.
Barthakur, Abhinava, Srecko Joksimovic, Vitomir Kovanovic, Rafael Ferreira Mello, Megan Taylor, Michael Richey, and Abelardo Pardo. "Understanding depth of reflective writing in workplace learning assessments using machine learning classification." IEEE Transactions on Learning Technologies 15, no. 5 (2022): 567-578.
Bhavnani, Sushil H., and M. Dayne Aldridge. "Teamwork across disciplinary borders: A bridge between college and the work place." Journal of Engineering Education 89, no. 1 (2000): 13-16.
Billett, Stephen. "Learning through work: workplace affordances and individual engagement." Journal of workplace learning 13, no. 5 (2001): 209-214.
Billett, Stephen. "Workplace participatory practices: Conceptualising workplaces as learning environments." Journal of workplace learning 16, no. 6 (2004): 312-324.
Brahimi, Nadjib, Fikri Dweiri, Imad Al-Syouf, and Sharafuddin A. Khan. "Cooperative education in an industrial engineering program." Procedia-Social and Behavioral Sciences 102 (2013): 446-453.
Braun, Virginia, and Victoria Clarke. Thematic analysis. In APA handbook of research methods in psychology, ed. H. Cooper., vol. 2: Research Designs, 57–71. Washington, DC: American Psychological Association, 2012.
Darling, Ann L., and Deanna P. Dannels. "Practicing engineers talk about the importance of talk: A report on the role of oral communication in the workplace." Communication Education 52, no. 1 (2003): 1-16.
Dehing, A., W. Jochems, and L. Baartman. "The development of engineering students professional identity during workplace learning in industry: A study in Dutch bachelor education." Engineering Education 8, no. 1 (2013): 42-64.
Dixon, Raymond A., and Ryan A. Brown. "Transfer of Learning: Connecting Concepts during Problem Solving." Journal of Technology Education 24, no. 1 (2012): 2-17.
Eraut, Michael. "Transfer of knowledge between education and workplace settings." In Knowledge, values and educational policy, pp. 75-94. Routledge, 2012.
Faulkner, Brian, Nicole Johnson-Glauch, Dong San Choi, and Geoffrey L. Herman. "When am I ever going to use this? An investigation of the calculus content of core engineering courses." Journal of engineering Education 109, no. 3 (2020): 402-423.
Fuller, Alison, Heather Hodkinson, Phil Hodkinson, and Lorna Unwin. "Learning as peripheral participation in communities of practice: a reassessment of key concepts in workplace learning." British educational research journal 31, no. 1 (2005): 49-68.
Garavan, Thomas N., and Claire Murphy. "The co-operative education process and organisational socialisation: a qualitative study of student perceptions of its effectiveness." Education+ training 43, no. 6 (2001): 281-302.
Guest, Greg, Kathleen M. MacQueen, and Emily E. Namey. “Applied thematic analysis”. Sage publications, 2011.
Halvorsen, Kristin, and Srikant Sarangi. "Team decision-making in workplace meetings: The interplay of activity roles and discourse roles." Journal of Pragmatics 76 (2015): 1-14.
Illeris, Knud. "Towards a contemporary and comprehensive theory of learning." International journal of lifelong education 22, no. 4 (2003): 396-406.
Jackson, Denise. “The contribution of work-integrated learning to undergraduate employability skill outcomes." Asia-Pacific Journal of Cooperative Education, 14, no. 2 (2013): 99-115.

Jonassen, David, Johannes Strobel, and Chwee Beng Lee. "Everyday problem solving in engineering: Lessons for engineering educators." Journal of engineering education 95, no. 2 (2006): 139-151.
Kolb, David A. “Experiential learning: Experience as the source of learning and development”. Prentice Hall, 1984.
Leckie, Gloria J., and Anne Fullerton. "Information literacy in science and engineering undergraduate education: Faculty attitudes and pedagogical practices." College & Research Libraries 60, no. 1 (1999): 9-29.
Liu, Qin, Doug Reeve, Cindy Rottmann, and Emily Moore. "Examining workplace affordance and student engagement in engineering co-op and internship literature." Canadian Journal of Science, Mathematics and Technology Education 20 (2020): 116-129.
Makki, Bilal Iftikhar, Rohani Salleh, Mumtaz Ali Memon, and Haryanni Harun. "The relationship between work readiness skills, career self-efficacy and career exploration among engineering graduates: A proposed framework." Research Journal of Applied Sciences, Engineering and Technology 10, no. 9 (2015): 1007-1011.
Martin, Rosanna, Bryan Maytham, Jennifer Case, and Duncan Fraser. "Engineering graduates’ perceptions of how well they were prepared for work in industry." European journal of engineering education 30, no. 2 (2005): 167-180.
McEwen, Celina, and Franziska Trede. "The Value of Workplace Learning in the First Year for University Students from Under-Represented Groups." Asia-Pacific Journal of Cooperative Education 15, no. 1 (2014): 55-67.
McMartin, Flora, and Jack McGourty. "Involving industry in the assessment process: Preliminary findings." In FIE'99 Frontiers in Education. 29th Annual Frontiers in Education Conference. Designing the Future of Science and Engineering Education. Conference Proceedings (IEEE Cat. No. 99CH37011, vol. 3, pp. 13A5-2. IEEE, 1999.
McNeill, Nathan J., Elliot P. Douglas, Mirka Koro-Ljungberg, David J. Therriault, and Ilana Krause. "Undergraduate students' beliefs about engineering problem solving." Journal of Engineering Education 105, no. 4 (2016): 560-584.
Mora, Higinio, María Teresa Signes-Pont, Andrés Fuster-Guilló, and María L. Pertegal-Felices. "A collaborative working model for enhancing the learning process of science & engineering students." Computers in Human Behavior 103 (2020): 140-150.
Paloniemi, Susanna. "Experience, competence and workplace learning." Journal of workplace learning 18, no. 7/8 (2006): 439-450.
Perkins, David N., and Gavriel Salomon. "Knowledge to go: A motivational and dispositional view of transfer." Educational Psychologist 47, no. 3 (2012): 248-258.
Sangwan, Kuldip Singh, and Rajni Singh. "An experiential learning-integrated framework to improve problem-solving skills of engineering graduates." Higher Education, Skills and Work-Based Learning 12, no. 2 (2022): 241-255.
Sawchuk, Peter H. "Researching workplace learning: An overview and critique." The Sage handbook of workplace learning (2011): 165-180.
Scanlon, Lesley. Becoming’a professional. Springer Netherlands, 2011.
Secules, Stephen, Nicola W. Sochacka, James L. Huff, and Joachim Walther. "The social construction of professional shame for undergraduate engineering students." Journal of Engineering Education 110, no. 4 (2021): 861-884.
Shaffer, David Williamson. "Epistemic frames and islands of expertise: Learning from infusion experiences." In Embracing Diversity in the Learning Sciences: Proceedings

of the Sixth International Conference of the Learning Sciences, p. 474. Psychology Press, 2004.

Sheppard, Sheri, Kelly Macatangay, Anne Colby, William M. Sullivan, and Lee S. Shulman. Educating engineers: Designing for the future of the field. Vol. 9. San Francisco, CA: Jossey-Bass, 2009.

Siller, Thomas J., Alma Rosales, John Haines, and Aaron Benally. "Development of undergraduate students' professional skills." *Journal of Professional Issues in Engineering Education and Practice* 135, no. 3 (2009): 102-108.

Strobel, Johannes, J. Wang, Nicole R. Weber, and Melissa Dyehouse. "The role of authenticity in design-based learning environments: The case of engineering education." Computers & Education 64 (2013): 143-152.

Strobel, Johannes, and Rui Pan. "Compound problem solving: Insights from the workplace for engineering education." Journal of Professional Issues in Engineering Education & Practice 137, no. 4 (2011): 215-222.

Tracy, Sarah J. "Qualitative quality: Eight “big-tent” criteria for excellent qualitative research." Qualitative inquiry 16, no. 10 (2010): 837-851.

Trevelyan, James. "Transitioning to engineering practice." European Journal of Engineering Education 44, no. 6 (2019): 821-837.

Wong, Silky SK, Jennifer A. Cross, and Phillip S. Mueller. "Impact of mentoring on practicing engineers: a meta-synthesis." Journal of Workplace Learning, 30, (2018): 415-411.

Zehr, Sarah M., and Russell Korte. "Student internship experiences: learning about the workplace." Education+ Training 62, no. 3 (2020): 311-324.