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Job Competencies: Experiential Learning For Engineering Students

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JOB COMPETENCIES: EXPERIENTIAL LEARNING FOR ENGINEERING STUDENTS

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ABSTRACT

This study investigates the learning of engineering students within the context of career-focused education. Often the technical and mathematical sciences on which engineering courses are built fail to explain the entirety of the landscape of practice. The main objective of this study is to capture various constructs produced by an undergraduate student while relating to his social interactions and experiences in an authentic workplace. The study also explores the student's responses to real-world contexts. This paper details a single case chosen using purposeful sampling, which investigates the phenomena of a student intern transitioning from engineering education to practice. The presented case is information-rich, and the intern's story provides a detailed insight into the complexity of a student's first encounter with engineering practice. This study highlights the conflict between engineering practice and engineering education and the corresponding emotional transition for graduate engineers. In particular, this study gives an intern's perspective of transitioning from education into practice and his emotional journey of self-learning, adapting to new situations, endeavouring to focus on clients' requirements, and ultimately finding his

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place on the engineering team. The intern's story supports the advocacy to reshape university engineering education so students' values, practices and expectations align better with practice.

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1. INTRODUCTION

The main aim of this study is to generate new knowledge on the phenomena of a student intern transitioning from engineering education to practice. It is asserted that transitioning from engineering education to practice is highly complex, critically important, and troublesome. (Hawse and Wood 2019, Trevelyan 2019, Baytiyeh and Naja 2012, Anderson et al. 2010) Due to misunderstandings about engineering practice, curriculum reforms addressing graduate attributes and workplace skills have not significantly improved graduate employability. (Trevelyan 2019) Furthermore, while limited, the literature exploring the design of workplace induction programs to assist graduate engineers in transitioning to professional practice is from an education perspective rather than the workplace. (Hawse and Wood 2019) As such, engineering students have incomplete views of engineering practice, and the type of work students expect to do in their future careers is vague. (Karataş, Bodner, and Ünal 2016, Goold, 2015) Most early-career engineers learn to practice by trial and error, and a fortunate few have helpful mentors to guide them. (Trevelyan 2019) This same author advocates reshaping university engineering education, so students' values, practices and expectations align better with practice. (Trevelyan 2019). It is anticipated that the findings of this study, investigating the transition to practice for engineering graduates, their readiness to perform job tasks successfully in real-world work environments and an account of graduates' early experiences of engineering practice will contribute to the knowledge on the design of undergraduate engineering programmes. The research question explored in this study is: what challenges does a student intern encounter when transitioning from engineering education to practice?

2. METHODOLOGY

This study captures the story of a student's first encounter with engineering practice. The undergraduate electronic engineering programme at TU DUBLIN, Tallaght, does not include formal work experience, and graduates' first encounter with engineering practice is usually after graduation. This study uses purposeful sampling: it proposes to capture the knowledge and meaning one undergraduate student who recently

completed an internship in engineering practice constructs from his social interactions and experiences in an authentic workplace and his responses to real-world contexts.

Contrary to quantitative logic, where large sample sizes are required, a single case is chosen because the case is of interest (Stake 2005). Case study research scientifically investigates a real-life phenomenon in-depth. Typically, a case study has a sample size of one. A single case may be chosen to explore deeply new phenomena (Miles and Huberman 1994) to gain rich and detailed insights into the complexity of social phenomena. (Collis and Hussey 2009) Purposeful sampling allows the researcher to focus on a phenomenon and to explore information-rich cases where the researcher can learn a great deal about issues of central importance to the education of future engineers (Schoch 2016). This study provides a detailed analysis of the transition to practice with the student as the context. While a larger sample size would generate a wider perspective of the phenomenon, only one intern with experience transitioning from engineering education to engineering practice was available to participate in this study. This is an information–rich case providing multiple insights into the context of this phenomenon.

An open-ended, informal interview was employed to explore and probe the student's experience of transitioning from university to practice and allow the interviewee to respond in his language. Open-ended questions were selected to reduce bias. The interview data were analysed qualitatively using an open coding system involving the grouping of survey response sections that share some common meaning. The findings result from the subsequent emergence of distinctive themes from the coded data.

3. RESULTS

The intern (alias Tom) is a final-year engineering student in Ireland who previously trained as a nurse in the Philippines. At the time of the interview, Tom had just completed an internship. The internship was his only experience in engineering practice. Tom was completing his final year of electronic engineering studies and looked forward to taking up a graduate engineering position with a multinational company.

A childhood interest in computers contributed to an interest in engineering, and Tom contrasts the "*risky*" nature of the medical field with his "*very big expectations*" of engineering. In addition to working with technology, computers and innovation, Tom's perception of an engineer is "*making life easier in terms of medical and other fields of work*." During his internship, Tom worked with an electronics company that provides solutions for the aerospace and consumer electronics industries. His work was in the applications department. Four themes were apparent from an analysis of the intern's internship account.

3.1 Theme 1: The contrast between engineering education and practice is evident.

Unlike college, working in engineering practice requires "*some client perspective*" and a real-world understanding of ethical issues, typically in the form of regulations, trade issues and special trade agreements with specific countries, some uses of artificially intelligent products and employee health and safety. The multidisciplinary aspect was a new experience for Tom.

It took a few weeks for Tom to understand his role in engineering practice. The "*quicker way of working, taking short cuts*" during the internship contrasts with the "*more structured approach learned in college*." While Tom likes objective solutions, "*I try to have a single value I can give to my manager*"; however, "*when I show the team how I did it, they were unsure*." Similarly, Tom's role did not have a "*structured objective it is more flexible … since some projects might not work out or we might need to go to another problem that the client is facing*". Time management also posed a challenge for Tom, as the focus at work was to "*deliver more rather than learn more …. and deadlines.*" There was no time allocated to the "*more in-depth learning*" that Tom required to get the work done.

Similarly, learning in the real-world contrasts somewhat with college learning; Tom says, "*I had to adapt to a quicker way of working, taking shortcuts… I can skip steps I learned in college*". Tom describes a technical project he completed as "*more about how you approach it and how you plan it rather than the technical content."* He learned that communications are more important than the technical. For example, Tom found it difficult to omit the highly specialised part of a technical user guide he developed, which "*will be available on our website and accessible to our clients, engineering students and non-engineer,"* and he had to "*make it simpler to read*."

3.2 Theme 2: Transition to practice is emotional.

Tom was very "*anxious*" and "*excited*" about the internship. He was anxious because it was "*a real-world scenario rather than a theoretical scenario of the classroom*." The excitement stemmed from the experience to be gained. However, Tom experienced many difficulties finding his "*place in the team.*" *"It's hard to level myself since I'm working with the team who have been there for years,*" and "*the team was really busy doing their own jobs, but I tried to arrange a meeting with them.*" "*I tried to catch up with them… I tried my best to learn everything and to apply that to the project I was working on*".

Tom was "*more confident*" using college-learned strategies compared to the company's ways. Rather than immediately adopting the company's strategies, Tom says, "*I combine both strategies and come up with my way that seems to work as well …I am more confident that way*". When his manager "*commended*" him for doing a

"*good job*" and his work was featured in the company's science fair, Tom says, "*that felt really good.*"

Tom developed a real-world understanding of ethical issues. As the company developed applications for customers, the company could regularly encounter customers in non-compliance with regulations, trade issues and special trade agreements with specific countries, usage of artificially intelligent products and employee health and safety. Tom struggled with the political reputation of some of the company's clients. Similarly, Tom works with a *"fear of making mistakes.*" For example, he is sometimes "*curious*" to learn by "*testing products at their limits while turning off warnings,*" but there is a part of him that is "*afraid."* Consequently, he tries to be "*careful.*"

When asked about becoming an engineer, Tom says, "*it fulfils what I wanted to do. I feel really great. I feel privileged to have another opportunity to learn what I really want to do and what I can contribute to the industry".* He adds that having the job offer before graduating "*is a very uplifting feeling. I have never felt this before*" and "*after nursing graduation in the Philippines, I needed to sit an exam to be registered and wait to apply for a job*."

3.3 Theme 3: Self-learning, planning, adaptability and client- perspective are key work strategies.

On the first day, Tom "*did not know what they wanted me to do and what they wanted me to learn?... I tried to structure what I needed to do and questions to ask my mentor/manager, what should I do next*? … *What are the goals they want me to do?"* Tom says, "*I tried my best to learn everything and to apply that to the project I was working on …. there was always room for me to make myself busy*". Tom relied on "*self-learning and perseverance*"; he says, "*I'll try and try until I get it*." Tom stresses the importance of "*self-learning*"; he acquired this ability when training for and practising nursing in the Philippines whereby "*there is no learning guide, they give us a list of topics, and it is up to us how we learn the stuff*." Planning is another skill that Tom employed during his internship. Tom learned this skill in nursing and in an undergraduate engineering module called Management Practice. Tom describes a technical project he completed as "*more about how you approach it and how you plan it*."

Tom lauds his "*adaptability*" skills; "*adaptability is where I engage as much as possible to learn things and become familiar with a company's tools so I can contribute*." *Having "some client perspective"* helps Tom understand his role; "*once I know what the client wants, it makes it easier."*

3.4 Theme 4: Engineering practice is a diverse community of team members, other engineers and clients.

While the team was helpful, Tom experienced many difficulties finding his place in the team. His familiarity with C++ software allows him to interact well with the software engineers who set the tool parameters to be used by the applications engineers. Having "*some client perspective*" helped Tom understand his role. Regarding employee diversity, while the company's employees are mostly Irish and American, "*only one I noticed different from my group, he prays a lot, and I respect that."*

Tom believed that placements/internships prepare students well for the real world of engineering. While his new job is in a different technology sector, Tom claims to "*have the advantage of confidence gained during the internship; I can try to adapt what I have learned there with [the new company*." While this new company is engaged in a very different technology, Tom is looking forward to the new job and regards his "*ability to learn,*" "*planning," "adaptability to environment and systems,*" and "*time management*" as the key skills he is bringing with him to the new company.

Regarding the hiring process for his new job, Tom says, "*they do not seem to care about engineering skills. They are only interested in problem-solving skills, people skills and soft skills.*" They "*focus on how you deal, solve, approach, plan, assess, validate, deal with the team, how you are going to function in their team and how you deal with them rather than how you deal with their product.*"

4. ACKNOWLEDGEMENTS, SUMMARY AND DISCUSSION

4.1 Acknowledgements

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4.2 Summary

This study found that the engineering student encountered four main challenges when transitioning from engineering education to practice: (i) adjusting from theoretical to practical strategies, (ii) emotional and social aspect is a new experience, (iii) how to respond to new methods and challenges and (iv) participating in a diverse community. This study highlights the contrast between engineering education and practice. Technical content, structured learning and objective solutions are integral to engineering education, while engineering practice involves clients, deadlines, shortcuts, multidisciplinary approaches and communications. There are also emotional differences. Confidence with college-learned strategies is set aside in favour of anxiousness and uncertainty about goals and methods. Additionally, there are social challenges; learning to communicate with and work with busy, experienced colleagues is particularly challenging. Furthermore, there are new ethical concerns. The intern outlines how self-learning, planning, adaptability and client perspective are key work strategies that assisted his transition from education to practice.

4.2 Validity of study

While this study has a sample size of one, the findings are valid; the intern is an information-rich case, and his story emerged from an open-ended interview which was analysed qualitatively using an open coding system. While a single case may be used to gain rich and detailed insights into the complexity of social phenomena. (Collis and Hussey 2009), a further study with a greater sample could be used to get a wider perspective of the research topic.

4.3 Research Question

The research question sets out to determine the challenges a student faces when transitioning from engineering education to practice. The outcome is the four themes. A significant challenge engineering practice presents is practising engineers' reliance on tacit knowledge, given that engineering education is based on explicit knowledge. The intern's story confirms that graduate engineers' over-attachment to objective solutions restricts both their vision of engineering solutions and the bigger picture of engineering practice, particularly where client factors and a background of incomplete information constrain real world practicality. In addition, a preference for a theoretical approach over subjective analysis contributes to communication difficulties. Furthermore, this creates an affective hurdle for graduate engineers to overcome when they begin working as engineers as evidenced by the intern who experienced many difficulties finding his "*place in the team.*" (Goold and Devitt 2012)

4.4 Implications for Engineering Education

The intern's story demonstrates that engineering education is somewhat misaligned with engineering practice. While engineering education comprises mostly technical knowledge, the business and organisation communities, which are so important in engineering practice, are often neglected in engineering education. This neglected aspect is evidenced in the intern's story as he struggled to set aside the technical content learned in university in favour of multidisciplinary problems, flexible objectives, client perspective, tacit knowledge, shortcuts, deadlines, communications, social interactions and ethical concerns, which dominate the landscape of practice.

This study provides further evidence for the divergences between engineering education and practice. A comparison of competencies required by practising engineers and competencies developed by students highlights gaps in preparation for professional practice. In particular, students' global, professional, thinking, ethical, business, teamwork, confidence and communications skills are inadequate. (Goold 2015)

The four themes emerging from the intern's story align with the research demonstrating that complex workplace relationships and social performances shape and are shaped by technical outcomes. (Trevelyan 2019) Learning from co-workers is the primary learning method in engineering practice and it is a means to understanding what is expected of new hires. (Korte 2009, Korte et al. 2008) However, while building relationships and mentoring relationships are key to navigating engineering practice, the most troublesome experience encountered by newly hired engineers is learning how the organisation's social system operates. (Korte 2009) Additionally, an ethnographic study of new engineers in their first job year shows that mentoring new engineers is "ad hoc and fleeting" and learning arrangements between new and more senior engineers are often rebuked due to corporate structure and hierarchy. New engineers can be isolated while struggling to find a place in their latest work, impacting their identity formation. (Davis et al. 2018) These authors conclude that systematically incorporating mentoring relationships with experienced practising engineers into the curriculum would assist the socialisation of new engineers and improve engineering graduate employability. (Davis et al. 2018)

It is asserted than an ability to do engineering work comes from the experience of working in an engineering environment, watching experienced engineers estimate, working out real problems and how they view the bigger picture. (Goold and Devitt, 2012) Internships provide graduate engineers with this tacit knowledge. One set of authors state that while preparing students for professional practice is the main objective of work placement programmes such as internships, it is critical to provide systematic learning guidance and effectively integrate interns into the organisation quickly. (Zehr and Korte 2020) They assert that students must also recognise connections between what they learn in the classroom and the workplace to apply knowledge from one environment to another effectively. (Zehr and Korte 2020) However, engineering is complex; for example, the engineering profession "consists of bundles of interrelated practices and material arrangements." (Rooney et al. 2013) Additionally, engineering practice comprises three types of communities: engineering (produces solutions to or manages problems of markets and societies), business (addresses the commercial needs) and organisation (group of people working within predominantly social structures and processes). (Korte 2019) Furthermore, engineers' work identity centres on their ability to be problem solvers, team players, and life-long learners in various milieus. (Anderson et al. 2010)

It is concluded that transitioning from education into practice is an important part of professional engineers' development. The intern's emotional journey of self-learning and adapting to new situations supports the advocacy to reshape university engineering education so students are equipped with skills such as self-learning, perseverance, planning, adaptability, client perspective and an ability to navigate the social system as they transition into engineering practice. Hence, incorporating an Engineering Practice module into engineering education would greatly enhance it.

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