From Students of Engineering to Students of Engineering Education Research and Practice: A Collaborative Auto-ethnographic Study

Luran Wangª, Gouri Vinodª, Yiwen Chengª, Xiaoyu Liª, Abel Nyamapfeneª and Jay Derrickª

*University College London*ª,

Corresponding Author's Email: a.nyamapfene@ucl.ac.uk

ABSTRACT

CONTEXT

The growth of engineering education research (EER) as a research discipline has led, amongst other things, to an increase in dedicated academic departments and degree programmes. The recently introduced MSc Engineering and Education at University College London is one such example. Current research suggests that the transition from professional practice and undergraduate disciplinary education to graduate level research and education is often accompanied by experiences of dissonance and discomfort. However, research on the necessary transformational learning pedagogies to support students undergoing this transition is still in its infancy. This study seeks to address this research gap.

PURPOSE OR GOAL

The literature on engineering education research (EER) suggests that individuals from engineering backgrounds who are moving into EER often find the transition daunting, as they have to learn new terminologies and to adapt to new ways of conducting research. In this study we seek to identify the challenges that students on the MSc Engineering and Education programme face, and the strategies they deploy as they undergo the transformation from a graduate engineer identity to an identity as an engineering education practitioner or researcher.

APPROACH OR METHODOLOGY/METHODS

In this study, a student-staff partnership comprising four current students on the MSc Engineering and Education and two academics teaching on the programme engage in collaborative autoethnographic research to explore the perceptions and experiences of the students on their learning journey on the MSc. Working together as a team of equals, we engage in online discussions, share personal narratives about our experiences on the programme, and collectively examine these shared personal narratives using thematic analysis.

ACTUAL OR ANTICIPATED OUTCOMES

This research will shed light on the motivations of students from engineering backgrounds to embark on engineering education research and practice, as well as the challenges they experience in adapting to a social science inquiry mindset. Specifically, the research will explore student experiences as they encounter and integrate new norms and worldviews inspired by social science perspectives, as opposed to the engineering-centric worldview that they were inducted into during their undergraduate engineering education and training.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Little has been written on developing transformational learning pedagogies for students from engineering backgrounds seeking to gain competence in engineering education research and practice. In this study, the student-staff research partnership works collaboratively with each other to identify the issues faced by students from engineering backgrounds to embark on engineering education research and practice.

KEYWORDS

Engineering education, collaborative autoethnography, student–staff partnership, threshold concepts, transformative learning pedagogy

Introduction

The growth of engineering education research (EER) as a research discipline has led, amongst other things, to an increase in dedicated academic departments and degree programmes (Borrego & Bernhard, 2011; Jesiek, Newswander, & Borrego, 2009). The recently introduced MSc Engineering and Education at University College London (UCL) is one such example. However, whilst there is a growing body of research looking at pedagogic and epistemological practices in EER-focussed graduate level programmes (see, for example, Adams, Pawley, and Jesiek (2012), Lopez and Garcia (2020) and Finelli and Mondisa (2019)), research on the necessary transformational learning pedagogies needed to support students is still in its infancy. This study seeks to address this research gap.

In this study we set out to identify the challenges faced by students on the UCL MSc Engineering and Education programme (hereinafter referred to as the MSc), and the strategies they deploy as they undergo the transformation from a graduate engineer identity to an identity as an engineering education practitioner or researcher. The MSc is offered simultaneously and flexibly in both online and face to face modes, and is made up of two compulsory core modules, Learning and Teaching in Engineering, and Practice, Innovation and Leadership, which introduce students to sociological and educational debates about engineering. Students also select two optional modules from the engineering and education faculties at UCL and complete a Dissertation. A key feature of the programme is the online discussion forum, and the dominant pedagogical approach is dialogic and interactive: typically, students are given materials, discussion questions and brief writing tasks before the synchronous sessions, which consist of presentations by a wide range of contributing academics, followed by questions and discussion. Our study is informed by recent work in research into doctoral education (see, for example, Adorno, Cronley, and Smith (2015) and Tyndall, Firnhaber, and Kistler (2021)) and in the fields of discipline-based education problems research (DBER) and SoTL (see, for example, Adendorff (2011) and Smit, Meyer, Crafford, and Parris (2017)) which suggest that the transition from professional practice and undergraduate disciplinary education to graduate level research and education is often accompanied by experiences of dissonance and discomfort. Potential reasons for why this transition can be daunting include dealing with issues and problems which are more social than technical, typically qualitative and not well-defined, ie 'swampy' problems' (Schön 1983).

Methodology

In this study, a student-staff partnership comprising four current students on the MSc Engineering and Education and two academics teaching on the programme engaged in collaborative auto-ethnographic research (Chang, 2013) to explore the perceptions and experiences of the students on their learning journey on the MSc. According to Chang, auto-ethnography is an autobiographical method whereby the researcher uses their personal experiences as primary data to expand the understanding of social phenomena. Collaborative auto-ethnography extends auto-ethnographic research by enabling multiple researchers to gather and analyse auto-ethnographic and self-reflective data about themselves systematically and collaboratively (Roy & Uekusa, 2020). The research methodology was approved by the UCL Institute of Education Ethics Committee.

All four students self-identify as female and had graduated in the previous academic year from undergraduate engineering degrees prior to enrolling on the MSc. Two of the students had obtained their bachelors degrees from China, one from the USA and the fourth one from the UK. The two academics self-identify as male, and one has a social science background whilst the other is a teaching-focussed engineering academic who has transitioned to EER via an education doctorate.

The ensuing discussion took place in an online focus group conducted via MS TEAMS. Due to the collaborative nature of our research method, the focus group was the most ideal option as it enabled the students to engage in discussion, with the two academics serving as facilitators. The discussion was guided by the research question:

> *What are the students' perceptions of their experiences throughout their learning journey on the MSc?*

The following specific questions structured the 90-minute focus group:

> *Why did you choose EE after your engineering degree?*
>
> *What challenges have you faced on the MSc?*
>
> *How have you felt when you received feedback on your assignments?*
>
> *Did you feel at any time that signing up for this course might have been a mistake?*
>
> *Has your understanding of 'critical thinking' changed since the start of the course?*
>
> *To what extent so you now think of yourself as an independent thinker in Engineering Education?*
>
> *Has anything changed for you as a result of this degree: ideas, outlook, ambitions, plans for the future?*

Students were encouraged to share personal narratives about their experiences on transitioning from an engineering student identity perspective to an EER researcher perspective over the course of their studies on the MSc. Following the focus group discussion, the two academics and the students individually examined the focus group transcript to identify students' changes in perception as they increasingly engaged with EER practices on the MSc.

Then, using a data-driven thematic approach (Braun & Clarke, 2006), all six of us – the four students and the two academics - individually read the focus group transcript, inductively identifying themes from the data. We then compared the identified themes and sub-themes that we had individually identified, and then working on a shared copy of the original transcript, we collaboratively re-read and re-coded the transcript to reflect our shared understanding of the emerging themes.

Findings from the Study

Why did students enrol on the MSc Engineering and Education?

Findings from the focus group suggest that students enrol on the MSc Engineering and Education for a variety of reasons. Some students enrol on the programme to enable them to study and explore the social and economic aspects of engineering in more depth. In response to why she chose to enrol on the MSc, one participant said

> *"… I don't only want to learn about engineering and science subjects, but also I feel interested in some social problems."*

Another participant said that she had always harboured an interest in the social sciences but when she decided to pursue an engineering career whilst still in high school, she had to drop all other subjects and focus only on science and mathematics which would enable her to qualify for entry into engineering degree programmes.

The study also revealed that some students decide to enrol on the MSc after having developed an interest in engineering education during their undergraduate engineering studies. One participant was dissatisfied with the quality of teaching on her engineering programme, and this prompted her to take an interest in engineering education. Explaining her desire to study engineering education, she said

> *"So I found that in my institution, there were many teachers with excellent scientific research ability, but relatively less good at teaching … and I began to think about what I would do if I were a teacher to improve the quality of teaching and make students more interested in the subject. So I wish to, uh, kind of understand more in this, uh, engineering education. So, um, and I think this, uh, master programme kind of, um, this is my - this part of interest."*

Another student joined the MSc, her interest in engineering education having been sparked by her involvement in the staff-student teaching committee during her undergraduate engineering programme:

> *"So, um, while I was studying the engineering major, I took part in the staff student community, and that was an important role to communicate with, uh, teaching faculty and students. I found something that was really different from my imagination to be, uh, an engineering student. I realised how much I didn't like engineering like the technical stuff and like, how much I prefer the educational side of things."*

Challenges faced by engineering students enrolled on the MSc Engineering and Education

Findings from the focus group suggest that most students enrolling on the MSc Engineering and Education from undergraduate engineering degree programmes experience difficulties with the academic writing style required on the MSc. One participant had this to say:

> *"I think writing the academic writing is one challenge for me, because when I am at the undergraduate, um, my dissertation is – I use the experiment's data to support what I want to explain. But now, um, the engineering and education I need to use, uh, not so much data, but just use some literature to support what I want to explain to the readers. So I think it's a little challenging for me to just use the literature to explain what I want to say."*

One student indicated that they were struggling to adapt to the teaching style required on the MSc because it was quite different from the learning and teaching approaches used on undergraduate engineering programmes and they had not had the opportunity to engage in the form of academic writing required on the MSc*:*

> *"And for me, I think it's the change of the teaching styles. And, for example, during my undergraduate period, I studied various mathematics, physics, data structures or algorithms and then programming, coding and developing software. So I had few opportunities to participate in the academic writing or, uh, writing of paper or like that. So, um, so I think it's, um, a little difficult for me to engage in this kind of teaching style rapidly."*

Students also struggled with assessment formats that were different from what they were used to on their undergraduate engineering programmes. For instance, one student said:

> *"Evaluation or the assessment is quite different. Um, for example, before I have had to pass the exam or the mathematics exam, the physics exam. But, um, there was less opportunity for me to write a paper or doing something like that, it's so different in the assessment way or the teaching style."* Another student had this to say: *"Um, I think for me like, the major thing was, um, just doing more writing in general. Um, so my whole undergrad degree, I'm pretty sure we did, like, … everything was exam based, or like some project. Um, so for me, it was like, kind of different."*

Student initial experiences and coping mechanisms

Most students were initially excited to be on the course, however as they started experiencing challenges with the required learning and assessment practices on the MSc, this often turned to a sense of confusion and disorientation. One student put it as follows:

> *"I was quite excited at first. I quite like challenges and the writing for me. … Uh, my instant thinking was to find a lot of evidence for me in this major. I have to find a lot of literature background. I have seen some problems already. So, um, so it was like an initial excitement [turning] to some confusion."*

Some students struggled to adapt to the learning and assessment styles on the MSc and this led to feelings of inadequacy and incompetence. One student expressed this as follows:

> *"And I felt, um, I felt that I was, uh, like, uh, less uh uh, for, uh, I think just less [confident]."* Another student also confirmed that *"… it was also a challenge for me and because I was not very confident about, um, I didn't know if I was doing well or not, and I …. I wasn't sure about this."*

To cope with perceived learning and assessment difficulties on the MSc, some students felt that they had to re-learn how to learn, as one student said:

> *"It was kind of hard, um, going back to doing like, um, literature review that wasn't like, um, for, like, research purposes. So, like, go, like, literally reading, like, educational purpose, education, educational, like papers and stuff. That was, like, a brand-new thing to me."* Another student also stated *"So learning how to do that was kind of, um it wasn't difficult, but it was definitely like, um, something I had to learn over the terms"*

Student insights into their struggles on the MSc

Looking back across the academic year, students reported having difficulties with self-management and self-evaluation when it came to self-directed studying. This was not the case with undergraduate engineering where the study goals were more explicit. One student observed,

> *"While I am studying, uh, this programme, I always feel like I have I have not achieved any goals. My assignment, it's quite different. When you were studying engineering course, you could set later goals for every day. So, you study this and practise this. But now here, when I try to do a little bit of research, you don't know what you're going to know. And then you couldn't probably control the time. But you cannot control the thing that you can't understand, or you can't see. … I feel very, very, uh, like, depressed because I have not achieved [my study goals]."*

Students feel that assessments on the MSc are tougher than the assessments on undergraduate engineering programmes. This is because unlike in undergraduate engineering programmes, MSc assessments have no definite answers. One student said,

> *"Um, it's just a lot tougher because it really doesn't seem like there's a right answer for, like, a lot of the assignments like, um, so it's like a lot of it is like our analysis of literature."*

Because of this, students feel that they can never be certain whether they have done well in a piece of assessment. Instead, they feel that the grades they attain are ultimately in the hands of the readers, and not solely under their control. Referring to this, one student said,

> *"I guess, Um, obviously you want the best grade possible, but it becomes a little like, um, I guess, like, um, it gives me a bit of anxiety just like writing it, because I don't know if it's going to be received the way that I wanted it to be received and even though, um, like I could put like, You know, all this effort in, it's, uh like at the end of*

the day it's up to the reader, and I think if they're like, 'Oh, this should have been added …'"

In general, students felt unable to predict their performance on the MSc, something which they could easily do in their undergraduate engineering studies. One student said,

"That's like there's - there's no like predicting, like [in] technical engineering, if you like. For the most part [in undergraduate engineering], if you study and you know, you practise some of the problems, more than likely you're going to be Okay on the test. It's predictable. Versus this is up to the interpreter." A second student also agreed with this, saying, *"For me as an engineering student, I know if I was doing it right or not, and for example, there was only one answer to a Maths problem, and I would be relieved that my code works. But, um, now, I don't know if I did the writing well. I have no idea. It's because the criteria or the metrics for assessment or other things are different."*

Critical thinking as a marker of progress on the MSc

The students felt that "critical thinking" was one of the key concepts that needed to be mastered on the MSc, and this was discussed at length. This statement is representative of the thoughts shared by the students,

"Based on my understanding, I think that we need to write the assignment as critical as possible. Um, maybe, like add some comparison, or maybe just dig more on one topic, have some deeper thoughts. Um, And I think, um, I try to do better in doing more critical assignment. Um, and I think there it's a long way for me to go to be critical, but I am trying."

Describing her journey towards mastering the concept of "critical thinking", one of the students said she had started off with basic understanding of critical thinking, and she had now developed a deeper, more nuanced understanding of the concept. Even then she was still not certain whether she had fully mastered the concept. This is how she put it,

"Um, at first I think critical thinking just means that, um, I need to talk about the, uh, optimistic aspect of this thing and then the negative aspect of this thing. That's my original thought about critical thinking. But then I think that, um, maybe I need to, uh, use different aspects to explain one thing and add more comparison from one perspective to another. And that's what I'm thinking. Uh, I don't know whether it's right, but I'm trying to do it better."

Other students expressed that they were also still struggling with the concept of critical thinking, even though they were almost at the end of the MSc. One of the two academics in the focus groups agreed with the students, suggesting that understanding critical thinking, just like trying to understand any other concept in the social sciences, is a never-ending process, unlike mastering certain engineering concepts, something which the students must adapt to. In the opinion of the academic, this marks a shift in the development of the students from a fixed engineering mindset to a more fluid, open-minded conceptual understanding.

Legitimate Peripheral Participation in the Engineering Education Community

The students viewed their year on the MSc as a form of initiation into the community of Engineering Education Researchers, and they were proud of their growing confidence as EER researchers as they progressed through the course. One student outlined her progression as follows,

"Um, I think, like, uh, in the beginning, I felt like I guess I don't have any authority to, like, say, I think about, like, these. Like, um, like literature that has been, you know,

written by the professionals, like in the sector. So, in the beginning, I was very much like, I guess, regurgitating what other people have said rather than what I think. I think as the course progressed, um, I guess I built up my confidence and, um, as I read other things, I had the confidence to say, 'Oh, this isn't really like that good an idea. This idea is better, like, kind of, um, being able to formulate my own thoughts and have that, like, confidence. Like learning more and more that I do have the authority to, like, say that, 'Um oh, I think this is more influential.' Like, especially in, um, like in getting girls to participate in all that. Um, I did, um, say that 'I don't think some of these ideas are that good.' Um, and I wouldn't have said that in the beginning, so yeah, I think definitely, I guess over time I, like, gained more of my bearings and became more outspoken."

This statement is consistent with the Legitimate Peripheral Participation view of how newcomers become experienced members and eventually old-timers of a community of practice or collaborative project (Lave & Wenger, 1991).

Transformational impact of the MSc

The MSc has encouraged some students to consider new career opportunities and directions beyond traditional engineering roles. One student remarked,

"So, I guess doing this course taught me that there is, like, other ways to apply my bachelor's degree."

The student went on to say that this was in line with the reason she had opted to enrol on the MSc instead of applying for a graduate engineering role,

"And that was the reason I joined in the first place was because I was kind of I didn't really feel like I fit in or wanted to pursue a career in, like, corporate like industry, which is what I would have done if it wasn't for this course."

Another student stated that the MSc had introduced her to the social science side of engineering. She had also taken the opportunity to take economics and psychology as option course modules in her MSC studies because, in her own words*,*

"… that was the knowledge that I have not, uh, learned like, uh huh, from teenage years. You know, sometimes I even think I should have learned those things earlier so that I could choose a different career path."

For some other students, the MSc had reinforced their reasons for choosing engineering as a career in the first place. "I think I quite enjoy the experience because I think it helps me to know what engineering means and what engineers can contribute for society. We, uh, begin to know the impact of letting more engineers to contribute to solving real problems, real projects. So, I think that's what I want." As a result, she was now looking forward to finding a role as an engineer after graduation.

From the focus group discussion, it was also apparent that the MSc had influenced some students' intention to pursue doctoral studies in quite different ways. A student who had wanted to go on to a PhD in a technical field had changed her mind and was now seeking to enrol on a PhD in Engineering Education*:*

"… I wanted to take this course and then, um uh, do a PhD in a technical field. But after this course, I have decided I want to go more into the education side of things."

In contrast, the MSc had instilled doubts in another student's mind regarding her desire to pursue a PhD in Engineering Education. She now felt that engineering education research was not for her. She was however still uncertain whether she would prefer to go into engineering practice after the MSc. Instead, she was opting to take up any suitable job following graduation to enable her to think about her long-term career goals.

Have students on the MSc experienced transformational learning? It is evident that the MSc has had a transformative effect on the students who participated in this research. Students have gained a heightened awareness of the social aspects of engineering, and they have also gained insights into some of the problems relating to engineering education, including gender imbalance, lack of diversity, and learning and teaching methods that are ill-suited to the needs of the 21st century.

At a personal level, the MSc has transformed the worldview of the students from a hitherto limited engineering-centric viewpoint to a broader worldview with broader perspectives and awareness of the world and its complexities. This has led to a re-evaluation of worldviews and perspectives, and an appreciation of the challenges and realities of the world and of their own impact as engineering professionals. For some, this has tampered the techno-optimism inculcated in engineering school, leading them to re-evaluate their career options, and adopting a more nuanced, mature, informed approach to career planning and career expectations.

Discussion

Students in our study speak of experiencing a sense of uncertainty and confusion as they struggled to adapt to the learning and assessment practices on the MSc. This finding is consistent with findings from other researchers. The study by Adorno et al. (2015) indicates that the transition into doctoral studies is characterised by uncertainty and chaos as the new doctoral students struggle to adapt to learning practices on doctoral programmes. The study of healthcare professionals on an MPhil in Health Professions Education at a South African university by Smit et al. (2017) also reveals that the transition from a health sciences perspective to the educational paradigm is accompanied by experiences of dissonance and discomfort.

The students on our study also report difficulties adapting to academic writing, critical thinking, and preparing and writing assignments. The studies by Adendorff (2011), Smit et al. (2017) and Tyndall et al. (2021) concur with these findings. Tyndall et al. (2021) conceptualise all these elements that students struggle with as threshold concepts, a term that suggests that a student's progress on the course ultimately depends on whether they have understood these concepts. Failure to understand the concepts would indicate that the student's difficulties with the course will persist, whilst mastering the concepts will open the student to an entirely new perspective and understanding of the course. Threshold concepts therefore serve as a gateway to mastering a course and they have been defined as learning concepts that signify *"a transformed way of understanding, or interpreting, or viewing something, without which the learner cannot progress, and results in a reformulation of the learners' frame of meaning"*(Land, Meyer, & Baillie, 2010).

Some of the findings from this study highlight the unintended consequences of an educational system in which academic pathways into STEM or the social sciences and humanities are decided early on in secondary school. One case in point is the student who enrolled onto the MSc to re-engage with her interest in the social sciences, she had been forced to abandon when she opted to follow a STEM pathway into engineering. The realisation by one of the other students during her undergraduate studies that engineering was not for her, may also be indicative of an education system that forces students to decide which career to follow early on in high school before they have had time to explore and engage with the full breadth of available career options.

Concluding remarks and Future work

This study focusses solely on the UCL MSc Engineering and Education and is based on a collaborative auto-ethnographic study comprising four students and two academic staff members; hence the findings may not be generalisable to all academic settings. However, the findings concur with those from other studies focussing on early career academics

transitioning into discipline-based education research, including engineering education research, as well as studies focussing on professionals embarking on graduate level DBER studies.

The MSc, which was launched in 2018-19, is continually evolving, particularly in relation to its pedagogical approaches. Changes over this period align well with the findings of this study: the most important have been an increasing emphasis on brief writing tasks throughout the programme which are not formally assessed, on encouraging and supporting regular and meaningful contributions and interactions on the online discussion forum, and more time given to informal tutoring. In general, since the programme started, pedagogy and course design has shifted towards a flipped-learning and learner-focussed approach, and this trend has accelerated as a result of the pandemic. This study suggests that these shifts and developments reflect the needs and preferences of students, as well as helping serve the future needs of the industry.

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