Engineering Educator Identity Development in a Socially and Culturally Embedded Discipline Specific Graduate Teaching Assistant Professional Development Program

Dr. Gokce Akcayir, University of Alberta

Dr. Gokce Akcayir works on the SPARK-ENG project as a postdoctoral fellow at the University of Alberta. Gokce received both her masters and Ph.D. degrees in Educational Technology. After completing her Ph.D. in 2018, she joined the Educational Technology, Knowledge, Language and Learning Analytics (EdTeKLA) research group at the University of Alberta where she completed a SSHRC postdoctoral fellowship. Later she participated in the SPARK-ENG project at the Centre for Mathematics, Science and Technology Education (CMASTE).

Dr. Marnie V Jamieson, University of Alberta

Marnie V. Jamieson, M. Sc., Ph.D., P.Eng. is a Teaching Professor in Chemical Process Design in the Department of Chemical and Materials Engineering at the University of Alberta and holds an M.Sc. and Ph.D. in Chemical Engineering. She is currently the William and Elizabeth Magee Chair in Chemical Engineering Design and leads the process design teaching team. Her current research focuses on engineering design and leadership, engineering culture, the engineering graduate attributes and their intersection with sustainability, learning culture, and continuous course and program improvement.

Kristian Basaraba, University of Alberta

Kristian Basaraba is currently an Instructional Coach for the SPARK-ENG (Scholarship of Pedagogy and Research Knowledge - Engineering) Program at the Faculty of Engineering at the University of Alberta. Throughout his 20+ years of teaching he has taught all levels of high school science in both a traditional and outreach setting. He earned his Master's of Science in Science Education from Montana State University where he explored the role that computer simulations have on students' conceptual understanding of classical physics. Kristian is very active in the professional development community and loves to share ideas and methodology for what happens in his classroom. One of his most recent achievements includes being awarded the 2020 Governor General's History Award for Excellence in Teaching for his project Exploring Colonialism, Creativity and Reconciliation with Skateboards.

Duncan Buchanan, University of Alberta

Duncan Buchanan, B.Sc., B.Ed., M.Ed., is a retired educator, consultant and administrator who works as an Instructional Coach in the Department of Experiential and Professional Education in the Faculty of Engineering at the University of Alberta. With over 30 years of teaching experience, he is excited about the opportunity to share his pedagogy and practice with Engineering professors and graduate teaching assistants.

Qingna Jin

Dr. Qingna Jin is an Assistant Professor in science education at the Department of Education, Cape Breton University, Canada. Before moving to her current position, she worked as a postdoctoral fellow at the Centre for Mathematics, Science and Technology Education (CMASTE), University of Alberta. Her research interests include dialogical argumentation in school science and STEM contexts, children's critical problem solving in the information age, and children's metacognition in learning.

Mijung Kim, University of Alberta

Dr. Mijung Kim is a professor in science education at the Faculty of Education, University of Alberta, Canada. Her research areas include children's collective reasoning and problem solving, scientific and socioscientific argumentation, and visualization in STEM education.

Dr. Janelle McFeetors, University of Alberta

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Janelle McFeetors is an Associate Professor of Elementary Mathematics Education and the Co-director of the Centre for Mathematics, Science, and Technology Education at the University of Alberta. Over the past four years, she has co-lead a team to develop and implement a pedagogical professional learning program (PLP) for post-secondary instructors. The PLP is grounded in evidence-based practices and supports the development of intentional teaching for educator identity formation.

Kerry Rose, University of Alberta

Dr. Kerry Rose is a project manager at the Centre for Mathematics, Science, and Technology Education, University of Alberta. Her research interests include Land-based learning, professional learning communities, and teacher agency.

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Engineering Educator Identity Development in a Socially and Culturally Embedded Discipline Specific Graduate Teaching Assistant (GTA) Professional Development Program

Gokce Akcayir[1], Marnie Jamieson[1], Mijung Kim[1], Duncan Buchanan[1], Janelle McFeetors[1], Qingna Jin[2], Kerry Rose[1], & Kristian Basaraba[1],

[1] University of Alberta, Canada, [2] Cape Breton University, Canada

Abstract

A discipline-specific pedagogical professional development (PD) program was created for Graduate teaching assistants (GTAs) in the Faculty of Engineering at a Canadian university to support and enhance GTAs pedagogical knowledge and competencies. As GTAs are employed to assist with course and lab delivery supporting their development as instructors and mentors may enhance undergraduate learning experiences. Situated learning theory informed the development of the community of practice based PD program. This case study explores the perspectives of GTAs who participated in the pilot PD program, including what they learned, how they engaged in learning about teaching, their emerging educator identity formation, and the challenges they faced during the program. GTAs appreciated the situated and culturally embedded nature of the program which allowed them time and space to consider pedagogical tools and practices and their application in their work with undergraduate students and in their own learning.

1. INTRODUCTION

Graduate teaching assistants (GTAs) play a significant role in shaping the learning experiences of undergraduate students [1] and they typically serve as a major point of contact for undergraduate students in higher education. As such, they have been termed the "first line of defense" toward improving educational experiences in universities [2]. GTAs often have a high level of interaction with students and they often act as agents of the course instructor, especially in large enrollment courses. As such, a positive impact on GTAs' teaching practices could directly improve undergraduate students' learning experiences [3]. GTAs often have little or no preparation for their roles as educators and as such may lack awareness of the significance of their role in higher education. They often rely on teaching approaches they have encountered as students, or those of their peers, whether those approaches have been successful or not [1]. For this reason, improving GTAs' pedagogical knowledge and skills could be seen to be a crucial step towards enhancing teaching practices in postsecondary education.

The potential of GTAs as higher education practitioners is often hindered by a lack of teaching opportunities beyond grading, demonstration, and supervision. Training and support systems for their preparation are also limited [4]. GTAs are expected to perform various pedagogical practices, including lab instruction, lab demonstrations, and grading student work while often experiencing minimal opportunities to fully comprehend the implications and rationale of best practices behind these activities. When opportunities for learning to teach do exist, they often fail to address the specific needs of different disciplines, despite the clear necessity for discipline-specific preparation [5]. Effective educators must possess not only subject matter knowledge and expertise but also pedagogical content knowledge that enables them to employ discipline-specific instructional strategies effectively [6].

As part of a larger project aimed at enhancing undergraduate pedagogy, a discipline-specific professional development (PD) program for engineering professors was developed by an academic center with a focus on mathematics, science and technology education in an education faculty at the same university. The PD program is intended is to move beyond PD as a passive, instrumental approach to gaining teaching skills toward professional learning (PL) as actively and deliberately enhancing one's teaching and understanding of teaching in a way that is "continuing, active, social, and related to practice" [7]. Subsequently, this pedagogical PD program was adapted for engineering GTAs, with an aim to enhance and support their professional learning. For clarity, we use "PD program" throughout to refer to the program offered to engineering GTAs that engaged them in professional learning about postsecondary engineering pedagogy.

This study was structured to investigate the GTA participants' experiences and development in the PD program intended to provide GTA opportunities to actively learn and reflect on pedagogical concepts and approaches as a community. This study was structured to investigate the participants' experiences in this program. The specific research questions that guided this study were:

- What features and content of the program did GTA participants highlight/recognize as comprising their opportunity to learn about teaching? (RQ1)
- In what ways did GTA participants begin to form an educator identity through their experiences in the program? (RQ2)

2.0 THEORETICAL AND CONCEPTUAL FRAMEWORKS

The pedagogical PD program was contextually developed to be discipline specific using Situated Learning Theory elements as shown in Figure 1. Situated Learning Theory [8] postulates learning occurs as a result of socially- and culturally-embedded interactions and relationships [9]. We understand situated learning to be "a process of interaction and relationship around a specific domain and which occurs within a social, cultural, and historical context, resulting in spontaneous learning" [9]. Learning takes place where the learners interact with a particular environment in a given context within a given community [10]. This domain is framed within a community of practice (CoP) in which novices participating in a process of apprenticeship become more engaged members and the established members also have opportunities to reflect on, share, and reexamine sociocultural practices of the community. Thus, the CoP is a reciprocal learning process in which the individual and the group are redefined continuously through temporal and spatial interactions [9]. In this sense, a CoP is in continual flux that evolves the enculturation of learners in specific culture and contexts [11].

Situated learning also emphasizes that learners embody the culture of the community to which they belong [12]; it is a process of becoming. As such, identity involvement is a necessary component of situated learning. Identity involvement refers to a process of becoming and feeling affinity to a particular target community [8]. Identity, as an understanding or sense of self, is dynamic in that "(re)forming of identity is continually undertaken through experiences and relating with others" [13]. Through participation in a situated learning experience, a

member develops an identity in relation to the CoP which is both influenced by and influences the multiple dimensions of themselves [14]. In this way, embedding learning within a context provides a space for meaning-making both in terms of the culture of the community and one's own identity [15]. These connected concepts are illustrated in the Figure 1 framework.

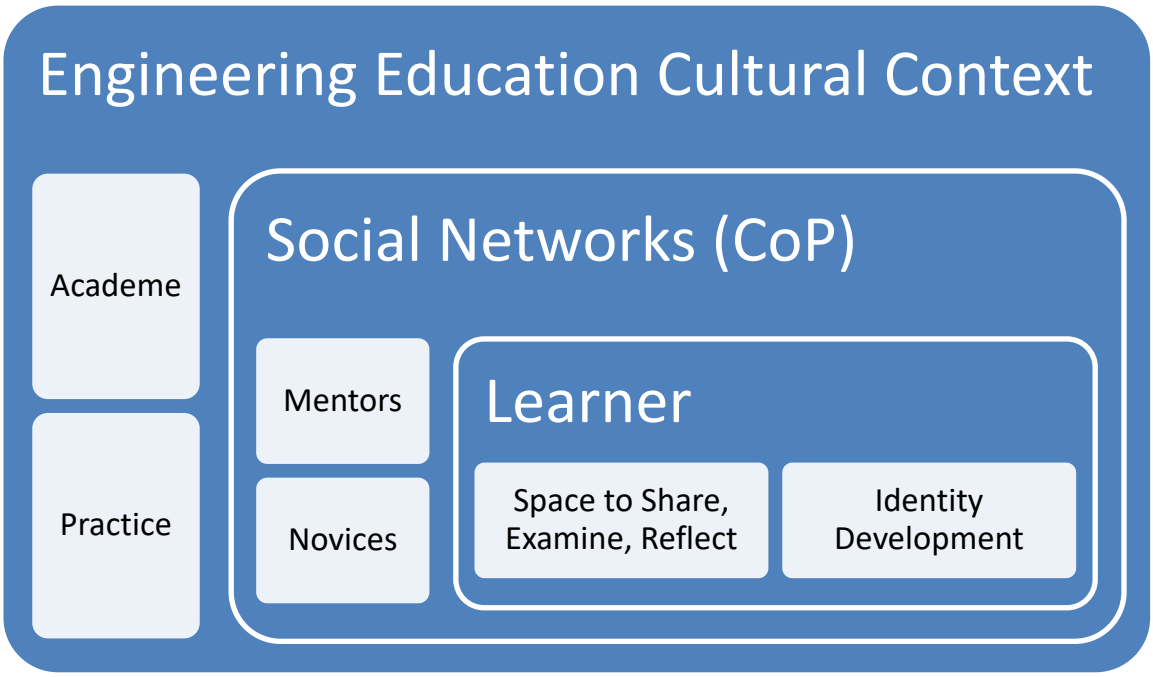

Figure 1. Situated Learning Theory framework with related concepts describing pedagogical learning and identity development in the context of a community of Practice embedded in engineering education culture.

3.0 METHOD

To answer our research questions, we employed a qualitative case study approach, which involves "an in-depth description and analysis of a bounded system" [16], to gain insight into how GTA participants experienced a PD program and whether they began to develop an educator identity as they engaged in the learning process. Through interpretive inquiry [17], we gathered context-specific information from diverse perspectives, revealing GTAs' learning experiences in the context of our research questions. In this section we further describe the participants, the GTA program adaptation, PD program implementation, the data collection and finally the data analysis.

3.1 Participants

This pedagogical PD program was conducted at a major research university in western Canada, spanning from January to April 2023. Two cohorts of GTAs from the Department of Electrical and Computer Engineering (ECE) participated, with the support of the Department Chair. The program was delivered through the university's online course platform and facilitated by the instructional coach. To select participants for the program, a promotional email was sent to

ECE graduate students and some GTAs were nominated by their supervisors and/or the department. Out of the 20 GTAs participating in the program, six individuals with varying teaching experiences volunteered to take part in this research study by sharing their insights and experiences in a focus group and in follow up individual structured interviews. All six participants were international students at different stages of their doctoral programs. They primarily worked in laboratories where their roles ranged from being a principal laboratory instructor to answering student questions as a teaching assistant.

3.2 GTA PD Program Adaptation

This pedagogical PD program for GTAs was adapted from an original two-year, four term program for engineering professors. The original program consisted of four themes, each theme delivered during an academic term and consisting of three modules as shown in Table 1. The first theme begins with modules that consider the philosophy of teaching and learning, including consideration of the nature of learners and nature of learning in post-secondary environments, along with equity, diversity and inclusion considerations. These modules lay the foundation for subsequent themes and modules by inviting participants to consider teaching as learner-centered and promoting equity and inclusion. The second theme encourages participants to consider how to foster active learning opportunities, by empowering students to learn through engaging in classroom discourse and short active components in lectures, while becoming aware of how they learn. The third theme considers course design more broadly, participants progress to consider more active learner-centered course designs, such as problem-based and team-based learning, along with designing assessment practices aligned with learner-centered pedagogy. In the final theme of the program dedicated to the scholarship of teaching and learning, participants are invited to consider their identity formation as an educator and how they might consider their own teaching practices as topics for self-study. Each of the 12 modules of the PD program for professors included asynchronous course materials and readings, required forum posts, a workplace learning task, a workshop facilitated by an instructional coach, a community of practice discussion, and opportunities for in class observations and feedback.

Much of the modification of the professor program to the development of the GTA program (Table 2) was up-front work: changing language to reference lab instructors and teaching assistants, choosing specific articles that referenced lab scenarios and altering workplace learning tasks so they were more meaningful to the GTA participants. Each modified module includes specific objectives, selected readings, video cases, podcasts featuring experts, reflective questions, and opportunities for the GTAs to develop and submit their own workplace learning tasks related to the module topics. Examples of these products include designing interactive learning activities for their students and creating learning objectives for their laboratory instructions. As the program proceeded, there was recognition that many GTA program participants were getting bogged down by the comprehensive, but lengthy material found in the asynchronous online modules. As a result, the GTA participants were given specific lessons, articles and videos with accompanying module reflection questions from each module. The learning and discussion in the module CoP was based on this material. By the time the program had reached the second of the four themes, it was conveyed to the participants

Table 1. Pedagogical PD program for engineering professors (original).

Theme	Module
Philosophy of Teaching and Learning	1. Nature of Learners
	2. Nature of Learning
	3. Equity, Diversity, & Inclusion (EDI) for Teaching
Fostering Learning Opportunities	4. Interactive Lectures
	5. Classroom Discourse
	6. Empowering Students to Learn
Designing Course for Learning	7. Problem-based Learning
	8. Team-based Learning
	9. Assessment Practices
Scholarship of Teaching and Learning	10. Forming an Identity as an Educator
	11. Professional Learning Communities
	12. Researching Educational Practices in Education

that the other portions of the module were valuable but not mandatory expectations.

Related to the efforts to make the GTA program more manageable and in conjunction with the decision to ask participants to engage only in specific aspects of the online asynchronous modules, the required module forum posts for each module were made optional. The forum posts were typically a series of questions designed to provoke reflection on the module material. Given that the majority of participants came prepared to discuss the module content, regardless of whether they overtly responded to the questions in the forum, it seemed to be a reasonable decision to eliminate the "mandatory" nature of the forum post activity. This was reinforced by participants' feedback that indicated they saw these written posts as "make work" tasks.

To better serve the needs of the GTA participants, the Nature of Learning module (T1M2) in the original professor PD program was divided into two parts. Part A focused on lesson introduction and the first 5 minutes whereas Part B emphasized lesson planning and creating effective learning outcomes. It should be noted that the concept of a lesson plan and a lesson plan template were provided in the program orientation session and linked to the concluding GTA PD program deliverable where participants submitted a comprehensive lesson plan related to one of their lab lessons. This final lesson plan incorporated all aspects covered in the SPARK-ENG TA Program. This final project was not a requirement of the professor PD program.

Given the compressed timeframe of the GTA PD program and the limited instructional experience of the participants, greater emphasis was placed on the pedagogical content in the first two themes. Emphasis was placed on the importance of getting to know students, creating a safe space for positive learning and engaging meaningful active learning strategies. The typical teaching experience of many GTA lab instructors participating in the PD program consisted of 15-30 minutes giving instructions at the start of a structured 3-hour lab where

Table 2. Pedagogical PD program for engineering teaching assistants (adapted).

Theme	Module
Philosophy of Teaching and Learning	1. Nature of Learners
	2. Nature of Learning, Part A
	3. EDI for Teaching
Fostering Learning Opportunities	4. Interactive Lectures
	5. Classroom Discourse
	6. Empowering Students to Learn
Designing Course for Learning	7. Problem-based Learning
	8. Team-based Learning
	9. Assessment Practices
Scholarship of Teaching and Learning	10. Forming an Identity as an Educator

undergraduate students followed lab manual instructions to complete the lab. The majority of the time GTAs spent with their students was interactive and often required them to troubleshoot lab procedures and respond to student inquiries. Consequently, the GTA program content was adapted to spend more time on developing lab lesson outcomes, the organization and structure of a lab lesson plan, and introducing the lab lesson. The module CoP focused on examining and questioning strategies for helping undergraduate students learn during this time. The use of Bloom's Taxonomy to direct proactive and formative discourse during the lab time was introduced then linked to the modules that covered concepts related to creating learning outcomes and developing assessments.

Other modifications of the professor program included significant changes in the delivery of three other modules. In Theme 3: Designing Courses for Learning, the separate problem-based learning (PBL) and team-based learning (TBL) modules were condensed into a single module. These two topics were approached in a synergistic way, as they related to students working in groups and solving specific laboratory problems. This differed from the professor program that approached PBL through a lengthier, student directed, course-based process and TBL through Tuckman's "Forming, Storming, Norming and Performing" team development lens. The final theme of the SPARK-ENG TA program, was the Scholarship of Teaching and Learning. Due to time constraints the GTA program only included the first module: Forming an Identity as an Educator. Most important in this module was the participants' development of a personal Teaching Philosophy Statement. The final two asynchronous modules in Theme 4, Professional Learning Communities and Researching Educational Practices in Education were not included.

Another aspect of the GTA program that differed noticeably from the professor program was the decision to include a specific peer teaching CoP session that revolved around participants leading a planned *Introduction to the lesson* or *First 5-minutes of a lab lesson* to their program cohort. Program participants were afforded a safe space to practice pedagogy, receive constructive feedback from an instructional coach and their colleagues and refine their lab introduction instructions before they stepped into the lab classroom. The participants responded very positively to this opportunity and many indicated at the end of the program that this was the one of the highlights for them.

The last significant difference in the GTA program was the inclusion of a Practical Teaching Strategies component that was shared by the Instructional Coach as part of two CoPs. These strategies were not part of the asynchronous modules. The content comprised a variety of relevant approaches to "basic" teaching. These skills, which included everything from visual format and presentation of handwritten and digital notes and media (i.e., don't use red whiteboard markers and six-point font!) to engaging students through eye contact, proximity, and volume (don't speak into the board while addressing your audience). Participants were often unaware of these best practices and appreciated their meaningful inclusion in the program.

3.3. GTA Professional Development Program Implementation

Recognizing that a GTA's tenure in the faculty is shorter and less predictable than a professor's, the timeline was condensed to a single academic term of 10 weeks rather than the four academic terms (3 months) over two years allotted for the professor PD program. This change facilitated funding and contextualizing the PD program as workplace training and simplifying the processes of recruiting candidates. Thematic modules were scheduled for weekly completion rather than the original professor PD program monthly module schedule. Themes were completed every three weeks rather than over the course of a semester. Due to the time limitations for the adapted GTA PD program, the last two modules were removed because of their strong focus on faculty members and the Scholarship of Teaching and Learning (SoTL) process.

The GTA PD program was facilitated by an instructional coach with over 30 years of experience as an educator. The instructional coach spent two months prior to implementation modifying the original two-year program module content designed for professors to make it more relevant to the GTA teaching experience and needs. As previously described in detail, modifications included reducing mandatory activities and content to respect the GTA time commitment and expected workload; replacing articles, videos, case studies and activities with more relevant substitutes; modifying workplace learning tasks consistent with the GTA and laboratory instructors' roles and responsibilities. It is important to note that the instructional coach was not involved in evaluating TAs and was not in a position of power with regard to their positions or evaluating their progress in the course beyond completion and attendance criteria. The instructional coaching was in a mentor role intended to provide support and expertise in pedagogical practices.

GTAs spent approximately 4-6 hours per week for three months on this program. Most of this time was dedicated to asynchronous, independent interaction with the online module content and developing their teaching products. The instructional coach led the 80 minute weekly synchronous CoP for each module. The instructional coach also visited the GTAs in their teaching environments where possible and used this experience to contextualize the weekly CoP module meetings. The GTAs had the opportunity to discuss their questions, observations, and experiences from the modules and their teaching or laboratory practices, relating them to the module topics during the CoP meetings. Recognizing the necessity of the instructional coach sharing their experience and expertise during the weekly in-person CoP, the time allotted for the GTA CoP meetings was increased from 60 minutes to 80 minutes and the 60 minute

module workshop provided in the professor program was omitted. This allowed the weekly synchronous commitment to be reduced while still providing an opportunity for participants to experience the active and student-centered pedagogical approaches described in the program and modeled by the instructional coach.

The GTA PD program CoP was a safe and supportive environment to try out new pedagogical ideas and teaching approaches for the first time. Throughout the program, the instructional coach helped guide and support the reflections and discussions among participants. The instructional coach was not a member of the professional community per se (i.e., he was not an engineering professor or graduate student teaching assistant) and thus acted as a facilitator to inform and guide the CoP discussion and activities. The CoP included module content-based discussions and the instructional coach's responses to the participants' questions. During several CoPs, participants presented overviews to their peers of how they would implement their ideas into the laboratory/seminar environment or practiced teaching elements including introducing a laboratory lesson and active learning approaches. The instructional coach included his observations of GTA teaching in laboratories and feedback on artifacts produced (e.g., course materials, workplace learning tasks, etc.) that were produced by the participants.

3.4 Data Collection

In order to gather data on the GTAs' experiences with the pedagogical PD program, multiple types of qualitative data were collected from the 6 GTAs participating in the research component. This included the products created by the GTAs throughout the modules. At the end of the program, the GTAs were invited to participate in a focus group discussion. During the focus group, they reflected on their overall experience with the program and then discussed various topics such as module content, time commitment, what they learned, and the aspects that were helpful for their teaching. They also shared the challenges they encountered. The 50-minute focus group session was video recorded and transcribed for subsequent analysis. Additionally, each participant was individually invited for a semi-structured interview to further explore their learning experiences and the development of their pedagogical approaches for teaching engineering students throughout the modules. These interviews lasted approximately 30 minutes each, and they were audio recorded and transcribed.

3.5 Data Analysis

The collected data underwent qualitative thematic analysis, using open and axial coding processes following the method suggested by Braun and Clarke [18] and Williams and Moser [19]. The research team individually reviewed the GTAs' products, transcribed data from the CoP meetings and interviews, and analyzed the data (open coding). After the individual review and analysis on the data, the research team met to share and discuss their coding and data interpretation. Diverse and consistent aspects and interpretations were shared and rewritten so the team could visualize how the ideas were connected and could be coded and categorized.

When the researchers saw the connection between ideas, they added these diagrammatically and recorded the rationale for the connection. In this process, the team read the data out loud and revisited their coding and interpretation.

Subsequently, at the next analysis session, the researchers revisited the ideas and the visualization of how ideas were connected and discussed possible themes arising from the analysis (axial coding). As a group, the team synthesized the earlier codes and identified the major themes. For example, quotes like, "I am a TA now, and I don't make any rules for the class... So I cannot see the benefits I gained from here in my work or my TAing" were reflected on the whiteboard as "level of responsibility" and "they don't design the class" during the first meeting. These ideas then shaped the theme of tension between what is being taught in the program and their practices as GTAs.

4.0 RESULTS AND DISCUSSION

Thematic analysis of the coded focus group and individual interview data based on our research questions (RQ1) and (RQ2) produced the five major themes summarized below.

- Time and space to think about and reflect on teaching and learning, both their own and that of their students. The PD program gave them an opportunity to process what worked and didn't work about their intuitive methods and consider new strategies (RQ1).
- Engagement with student centered pedagogies and the impact of active learning strategies on the effectiveness of learning and retention of learning (RQ1).
- The explicit recognition of metacognition and metacognitive skills in their own learning and the learning of the students they teach (RQ1).
- Recognition of the value of experiential learning in a community of practice and the value of experiencing student centered and active learning pedagogies in the CoP (RQ2).
- The emergence of an engineering educator identity (RQ2).

Discussion, supporting interview data and data analysis of each of the five themes in the context of the research questions follows.

4.1 Space and opportunity to think about teaching and learning

During the interviews, some of the GTAs reflected on their novice approaches to teaching before the program. One said: "I had some vague ideas about teaching even before I take [sic] this program, but this program helped kind of shape my specific ideas about all these." As exemplified by this quote, the majority of GTAs did not possess a clear understanding or a strategically-designed plan for their teaching before the program. A key element of these learning opportunities could be seen as space, by which we mean the confluence of setting aside time to think and reflect, to gather with others to discuss, to receive input of information and ideas, and to have this arise at a time that coincides with assigned teaching-related tasks. Thus, the program provided space for the GTAs to thoughtfully consider and learn about teaching.

The participants thought about the impact of the learning management systems and the delivery of the course with respect to their ability to engage with the materials because of time constraints and their other commitments. "It was the time commitment**,** so the material on the e-class, all of the materials was amazing, but it's impossible for me to go through all of them in

three hours, so, or four hours, the entire commitment that we made for this program." In their feedback with respect to the course they were thinking about pedagogical strategies that could be employed to enable time efficiency and suggested options for focusing on what they considered to be the relevant parts: “one thing the reading component can be either shorter or summarized.” Participants observed when they were confused by the materials and the arrangement. They had ideas for how they would revise the content to make it more effective: “I kind of understand why you introduced that interview at first. But really, I think it might be better to adjust some of them to put them later in the module. Although it was adapted, the program filled the learning space with more content than participants had time to process. These observations further point to a need in engineering education for more time, space and priority to learn, think and reflect on pedagogical strategies. Connecting to the theoretical and conceptual framework in Figure 1, the available space and time need to match with the time needed to share, explore, and reflect on knowledge.

GTAs mentioned their previous approaches included improvising and intuition, “At the time, I used my intuition, trial and error. ...After attending this course, I found out that there is some sort of strategic ways.” This observation underscores the notable absence of sufficient space for GTAs to engage in thoughtful consideration of pedagogy. In this absence, GTAs found themselves compelled to depend on their “intuition” to inform their teaching practices. Some GTAs recounted how they had few previous ideas about how to help students:

“Because before that [the program] everything was like a trial and error, you teach some courses, you get some feedback from the students, … but this course provides this amazing opportunity to learn about everything, without having the pressure of actually teaching anything.”

Even though not all participants directly commented on the development of their educator identity, their statements about the pedagogical content show that they were beginning to think like educators. As the GTA who shared the above quote articulated, resorting to “trial and error” and adjusting teaching practices based on student feedback may have been the only option available for GTAs to contemplate and develop pedagogical knowledge prior to the PD program. Nevertheless, this approach does not necessarily support sustained and significant pedagogical development and may not consider the specific needs of diverse undergraduate students who are taught using 'trial and error' pedagogies.

After having experienced the program, GTAs commented about how the depth and specificity of the program enabled them to think about teaching and learning. Some mentioned particular areas of the pedagogical curriculum, including Bloom’s taxonomy and diversity among learners as useful content for their teaching. One GTA said: “Bloom's Taxonomy for example, was amazing, I was not aware of these taxonomies.” Drawing this particular framework into the awareness of the GTAs allowed them to learn how to ask better questions when interacting with students, thus impacting their teaching practices.

Another GTA reflected on his opportunity to learn and was able to identify many of the program elements, or “techniques,” related to teaching:

“So overly, [sic] I learned a lot. So, before joining this amazing program, I had some idea

about, different people have different learning styles, but through this course I learned a lot. Learned about how many in variation and diversity we have in the learning and teaching experience, I learned a lot of techniques to manage my future classes. For example, how to conduct, how to create this course plan, how to manage each individual session of my lectures, how to plan ahead and lots of other amazing techniques. For example, I think I already mentioned this about two- stage exams, they are also, so yeah, thanks to this program I learned about all of these things."

These statements highlight how the participants started to reflect on what teaching and learning means in their contexts and to them. Some of their understandings were in the early stages of emergence and would require further consolidation, yet, it was evident that they became more aware and reflective about their actions toward teaching undergraduate students.

4.2 Learning approaches to implement student-centered pedagogy

The program included many constructivist pedagogical approaches, such as classroom discourse, problem-based learning, team-based learning, and interactive lectures. Its overarching goal was to guide GTAs in comprehending the significance of placing students at the center of the learning process. As the program concluded, GTAs demonstrated a growing understanding of and appreciation for student-centered pedagogy. They commented:

"The most valuable really is for me is empower students to learn."

"I think interactive lectures really make the students engage in the learning process, because for engineering labs it's somehow important if the students can actively engage in the material that you are trying to teach them."

"In the future, I focus on the, thinking about how my students think about the concepts and why they are struggling, and how I can just maybe switch some, something, very minor things, and they become more proficient in their understanding."

"Making students active and engaged all the time, that was something that I had no idea before, and I believe that's one of – or if I want to rank all of these strategies that we discussed in this course, active learning is the top important thing in my mind if I want to do some instruction in the future."

The GTAs' shifting perspectives on student-centered pedagogy may be interpreted as epistemological progression in their educator identity development. By employing key terms such as "empowerment," "engagement," and "interaction," and offering detailed explanations, GTAs emphasized that their intention to embrace student-centered pedagogy is not merely a result of restating course material but a genuine comprehension of the underlying reasons and methodologies. They demonstrated a clear understanding of the rationale and importance of shifting toward student-centered pedagogy. Furthermore, participants explicitly recognized the significance of engaging students through effective approaches proposed in the modules:

"The first two modules show how to engage students and how to be a good instructor… My teaching techniques improved a lot ...[with] problem-based learning or project-based learning."

> "So, as a TA, I have many things to consider, especially two stage exams…. I will definitely try that as my first teaching experience in the next semester. And the lesson plan was the most powerful thing. It has a blueprint of everything and I probably plan ahead for all of my courses."

GTAs mentioned various tools and techniques that could be effective to help students, such as two-stage exams, to support students' active, collaborative engagement in their learning. Two-stage exams allow students to collaborate in a second stage after having completed the exam first individually. Notably, this also aligns an assessment practice with using an approach like problem-based learning that is also active and collaborative. One participant concluded, "that's actually learning, giving students the opportunity to go back and forth and fix their mistakes… that's the definition of learning [to me]," demonstrating their understanding and incorporation of a student-focused approach. GTAs were shifting their sense GTAs were shifting their sense of what constitutes learning from students receiving information in lectures toward constructing knowing from their experiences of being active.

4.3 Recognizing metacognition and the role it plays in learning and identity development

Although many engineers and engineering students use metacognitive processes successfully, they may be unaware of what metacognition is and the role it plays in lifelong learning, professional development, course design, learning activity design, teaching, and learning. This revelation can change how learning and development are viewed. As one GTA noted: "So how I think the most valuable is in the entire module with metacognition. And the reason is both it was very novel for me. Despite the fact that I was using some sort of metacognition."

The GTAs who participated in the PD program are graduate students most of whom have completed an undergraduate engineering degree requiring the completion of a capstone team design project. This experience can be pivotal in the transition from the role and identity of an engineering student to that of an engineer in training [20]. Metacognitive skills and experiences facilitate student development as students reflect on their experiences and make sense of it.

Metacognitive skills and experience play a pivotal role in the liminal space where identity transitions occur. GTAs have made a transition from undergraduate engineering student to engineer in training, engineer and/or graduate student depending on their career arc. Irrespective of their stage of engineering identity development, they are in the liminal space with respect to educator identity development. Another GTA commented:

"So the most important part for me is metacognition. And I think in this module we learn about how to engage students how to learn by themselves. And I think this is the most valuable skills for students."

In addition, the GTAs recognized the connection of metacognitive skills with empowerment and the ability to identify one's own learning gaps and needs:

"I mean the most valuable really is for me is empower students to learn. Like metacognition obviously."

Learning about metacognition allowed GTAs to identify their own experiences of learning in the

context of engineering education and extend it to the learning experience of the students they are teaching. These connections further illustrate the social embeddedness of the GTAs personal learning as their learning is extended to empowering the undergraduate students they teach.

By the end of the program participants had begun to think of themselves as teachers and educators of engineers. For some this was the first time that they recognized that they were *Teaching* Assistants and not teacher's *assistants*. The shifting emphasis of their role and emerging identity as educators changed their perspective of their role and their approach to the lab classroom and interactions with the undergraduate students.

4.4 Recognizing CoP and the value of learning as a community

Weekly CoP meetings allowed participants to share their perspectives and to collaboratively construct knowledge through discussions. Additionally, they provided an opportunity for participants to reflect on their developing educator identities [21]. A GTA commented on CoP meetings:

"I was more able to participate more actively in the co-op meetings... It helped me a lot to, like, engage with the other peers and get their opinions, I also shared my opinions and kind of exchanged ideas and learned a lot from that."

As emphasized by the GTA, the interactions within CoPs exhibited a reciprocal dynamic. It was crucial to articulate the evolving understanding of effective pedagogical strategies, with other participants stating, "exchanged ideas and learned a lot from that." This explanation highlights the strength of CoPs in fostering reciprocity, as a community cannot thrive through a one-way interaction where the instructional coach imparts information to the participants. We believe that sustained change in teaching practices follows from these types of transformative experiences.

When the GTA emphasized that they were "able to participate more actively," they began to recognize what constituted an active learning experience, a point also highlighted by some others: "I think the most interesting part is about the general [CoP] meeting … because the structure is very amazing and … the meeting I feel like is really active so I really enjoy it on this part." It was evident that thinking and talking about "teaching" together with others in similar situations was meaningful and effective for GTAs. In this way, the CoP contributed to the space that GTAs needed to focus their thinking on teaching within the many demands of being graduate students.

GTAs highlighted the significant role the instructional coach played in the CoP meetings as a facilitator and indicated that they observed his educational practices. One of them expressed it as: "He can be a role model for many of us in terms of a teacher." The importance of observing an experienced teacher who embodied the ideas in the program modules provided coherence across all elements of the program.

Beyond simply recognizing the instructional coach as a role model, GTAs also took the opportunity to identify what pedagogic moves the instructional coach made that demonstrated that he was a master teacher. What this indicates to us is that the GTAs were able to connect the ideas they were reading about in the modules with actions they were observing in an experienced

teacher. They mentioned:

"The [instructional coach], for instance, collaborate[d] with all students. He tried to make eye contact with all the students. That was something that I saw, but I didn't notice it as an important teaching feature that an instructor should have in class. But after having a lecture about …interactive learning … it grabbed my attention more toward these behaviours."

"The synchronous module [CoP]was amazing. Every time [the instructional coach] had something to amaze us with, a new teaching style or a new engagement technique and yeah, I really appreciate everything about the synchronous part."

As these comments indicate, the CoP meetings were perceived as an important learning activity that functioned as a collaborative learning environment. At the CoP meetings, GTAs observed, noticed, and appreciated specific examples of the instructional coach's modeling such as making eye contact with individual learners and embedding certain pedagogical strategies in the sessions. The GTAs' awareness and paying attention to these mostly unspoken pedagogical practices during the CoP are valuable aspects of their learning and growth in the program. They could observe and notice how teachers nurture learners and how instructional strategies could be implemented in classroom interactions to engage learners. The community-based interactions were beneficial and crucial for them to reflect on what teaching means and how it can be practiced. This type of benefit through community-based interactions was also highlighted by Harper et. al. [22] in education practice and by Jamieson and Shaw in engineering practice [23].

4.5 Emergence and challenge of educator identity formation

Throughout the program, we aimed to provide opportunities to GTAs to reflect on their roles as educators or someone who is responsible for helping students with learning. We see this as an emerging process of forming an educator identity. Two participants noted:

"Regarding the identity and perception of myself, as I mentioned, it changed a lot."

"Definitely my perception as an educator or if you want to call it educator of engineers changed a lot."

While these reflections were quite general, they demonstrate an emerging awareness of themselves as educators – an identity that they can continue to form. These nascent statements are meaningful as educator identity emerges and signified an early understanding, coming before more fundamental changes in their core beliefs and values as educators. We expect that as their sense of themselves as educators becomes consolidated over time that their voices as educators will also grow and result in more articulate expressions of their educator identity.

One GTA provided an example of transferring the acquired knowledge to a different academic activity (e.g., presentations) which could be interpreted as a sign of an emerging educator identity as suggested by Kajfez and Matusovich [24]:

"I try to apply all of these features in my own presentations because … the only chance that I have so far is to present something that I know to other people that have no idea about."

We also observed challenges surrounding educator identity formation. With the limited opportunities to design or teach the whole courses, the majority of the participants did not describe themselves as educators fully, but only as teaching assistants who need to follow the instructions given by professors or by prescribed course materials. Some of the GTAs'

comments reveal that they did not feel empowered because they could not immediately transfer some of their learning to their practices: "I think all these modules are useful. It's just in the context of TA teaching, I think some of them are not that immediately can be used in the TA context." Another explained:

"Forming an identity as an educator is somehow more valuable for our own future teaching career. … We have two roles here at this university for TAing. One is teacher assistantship and the other is lab instructor. So I don't have many [opportunities] of these as a teacher assistant. Because I am a TA now and I don't make any rules for this class. But for future courses, could be so useful."

We see here that this GTA had a strong sense of his identity as a teaching assistant that was shaped by the role he fulfilled. He also pointed to a distinction between what it meant to be a teaching assistant and lab instructor. These two different identities were echoed by another GTA who explained, "EDI for teaching is kind of the thing that can be applied to all roles in a classroom. Either teacher assistantship, or lab instructors." Interestingly, broader issues that an educator would need to be aware of and enact were seen as transcending these identities. We suggest that perhaps this insight on the part of the GTA could be a promising, nascent shift toward an identity as an educator that is lived out in any classroom context or role where the aim is to lead the learning of students.

The value of the pedagogical PD program being investigated here is that the GTAs became open to the idea that educators have a particular kind of identity and that discussions toward forming an identity as an educator occurred within the CoPs and were prompted by the module content. This provides an intentional opportunity for forming an educator identity that is contrasted with the literature cited earlier (see [25]).

5.0 CONCLUSIONS

The features and content of the professional development program GTA participants highlighted and recognized as comprising their opportunity to learn about teaching were time and space to learn, engagement with student centered pedagogies and the recognition of metacognition and metacognitive skills in their own learning and in their teaching practice. GTA participants began to form an educator identity through their experiences in the program when they engaged with student centered pedagogy and metacognition in the CoP. Participants realized their value with respect to student empowerment and learning. GTA experiences in the discipline specific socially- and culturally-embedded CoP gave participants a safe place to explore their current and future roles and potential as engineering educators.

Given the high numbers of GTAs and their often overlooked contribution and roles in higher education, a culturally and socially embedded model grounded in Situated Learning Theory for

the preparation of engineering GTAs for their roles and responsibilities in university labs and classrooms appears to have contributed to their emerging development as engineering educators and has given them the opportunity to share and reflect on pedagogical strategies and concepts to enhance undergraduate students' learning experiences. Enhancing the experience and the development of the GTAs as effective engineering educators may have a positive impact on undergraduate engineering education with respect to increasing the use of active learning and metacognitive strategies.

This study provides an evaluation of the experience of GTAs in a discipline specific program designed to enhance GTAs' understanding about teaching and learning and their educational practices. The results indicate that supporting the development of GTAs' educator identity in this manner can help them to plan and apply better educational practices earlier in their teaching careers and navigate the liminal space as they transition from engineering graduate students to engineering educators. Since some GTAs aspire to pursue an academic career, training efforts for GTAs may also contribute to developing the teaching practices and educator identities of future professors.

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