THE IMPLICIT CANADIAN RESEARCH AGENDA FOR ENGINEERING EDUCATION: 2019

Renato Bezerra Rodrigues, Jillian Seniuk Cicek, Marcia Friesen
University of Manitoba
bezerrar@myumanitoba.ca

Abstract – *Given the growth of the engineering education community in Canada, we argue that a research agenda that reflects our own identity and interests is needed. To start this conversation, we conducted a content analysis of the 2019 CEEA-ACEG conference proceedings to investigate the implicit Canadian research agenda for engineering education. We analyzed five characteristics: publications’ stream, level of collaboration, authors’ affiliations and, more importantly, their research topics and areas. We found that the Canadian EER community is very practice-oriented, collaborative and that most universities were represented at the conference. Also, seven main research areas were identified: Assessment, Teaching and Learning, Students, Faculty, Organizational, Engineering Education Discipline, and Philosophy of Engineering. Among these areas, Teaching and Learning is, by far, the one that received the most attention.*

Keywords: Engineering Education Research, Canada, Research Agenda, Content Analysis.

1. INTRODUCTION

The field of Engineering Education Research (EER) in Canada is relatively new, especially if compared to countries such as the United States. However, engineering educators in Canada have engaged with the global EER field, including the American EER community and their associated journals, conferences, and their 15-year old research agenda [1], long before the formal birth of EER in this country [2].

More recently, the field of EER in Canada has had a steady growth [3] and researchers have started creating their own community. The evolution of the annual CEEA-ACEG conference (from 90 papers in 2010 to 138 in 2019, and the addition of a peer-review process), along with the creation of Special Interest Groups [4], Communities of Practice [5], and graduate programs specialized in engineering education at the University of Toronto and University of Manitoba, serve as evidence for evolution and the process of formalization of EER in Canada.

To continue moving forward, we argue that it is critical for the EER community in Canada to develop our own identity and goals that reflect our specific contextual concerns and interests. In that sense, we agree with [2] and believe it is time for Canadian engineering education to have its own research agenda – one that creates “spaces to

respond to Canada-specific concerns and interests” [2]. A coherent, strategic research agenda is important because it can raise awareness for the most pressing areas and enable researchers to conceptualize how their research can contribute to the larger goals of the community [6]. It can also enable EER researchers to work together to increase their research’s impact and visibility and create a strong, vibrant field of EER [6] in Canada.

The first step in this process is to identify the priorities and interests of those directly and actively involved in engineering education – researchers and instructors. Previous research has been done to determine the topics of interest of the EER community, but none is in the Canadian context. For example, both [7] and [8], as one aspect of their research questions, looked at research topics in the *Journal of Engineering Education’s* (*JEE*) publications between 1996-2001, and 1993-2002, respectively. In their turn, [9] looked at the global community’s topics of interest, analyzing four engineering education journals and conferences around the world between 2005 and 2008. Additionally, [10] also investigated research characteristics, including topics, in *JEE*, but from 2000 to 2009. More recently, [11] did a methodological review, which included investigating the research topics of four engineering education journals in 2018. The only study that analyzed the Canadian EER was conducted by [3]. They focused on the evolution of the field along the “practice-theory” spectrum and the research rigour between 2004 and 2017 in CEEA-ACEG publications.

Hence, this larger research study aims to fill a gap by examining Canada’s EER areas and topics of interest and proposing a Canadian EER agenda. This work has begun by analyzing the most recent year of CEEA-ACEG conference proceeding publications, pre-COVID-19, answering the question: *What was the implicit engineering education research agenda in Canada in 2019?*

We will conduct a content analysis of the data and analyze five characteristics of the publications, which are: publications’ stream, level of collaboration, authors’ affiliation and, more importantly, their research topics and areas. The next section of this paper will explain in detail the methodology of this research. Then, we will present our findings and compare the Canadian context with the literature. Lastly, in the conclusion, we summarize our findings and present the next steps of this research.

2. METHODOLOGY

This study aims to examine the topics and areas of interest of the engineering education research community in Canada. For that, we conducted a content analysis based on [12], where the research procedures were as follows:

1. *Content selection*: To identify the trending research topics and areas in EER in Canada, we chose to focus the analysis on the CEEA-ACEG conference proceedings because of three main reasons: First, it is the main Canadian venue for sharing research in engineering education; second, it has hundreds of publications available on various topics in both practice and research streams; lastly, conferences have a quicker and less rigorous publication process than journals. This makes the conference papers more reflective of what is being researched in the moment, and enables more authors to share their work. This paper will report on our findings from the analysis of the 2019 proceedings. This scope was chosen because the year 2019 has 138 publications – which offers an adequate sample size for preliminary findings and refinement of the methodology – and it is the most recent published proceedings pre-COVID-19. Full peer-reviewed and regular conference papers in both streams – practice and research – were examined.
2. *Conceptualization*: To address the research question proposed previously, the content analysis focused on five variables: 1 – affiliation/institution, 2 – number of authors, 3 – publication stream, 4 – context/topic, and 5 – purpose/research area. We chose to analyze variable 1 to investigate how EER research is distributed across institutions in Canada; 2 to identify collaboration patterns; 3 to explore the research-practice spectrum; and 4 and 5 to identify the implicit research agenda. The conceptual definition of each variable is outlined below.
3. *Operationalization*: The coding process was primarily deductive, using the Engineering Education Research Taxonomy [13], which is the most comprehensive taxonomy and provides evidence of both validity and reliability [14]. Although there were explicit efforts to make the taxonomy as global as possible, it still focuses on United States' context. The EER Taxonomy [13] was used as the initial codebook for coding variables 4 (context/topic) and 5 (purpose/research area). Variable 1 (affiliation/institution) was coded *in vivo*, 2 (number of authors) was counted and assigned a numerical value, and 3 (publication stream) was either *practice* or *research*, based on the classification proposed by the conference. The papers were analyzed based on their titles, abstracts and keywords, trying to match as close as possible the vocabulary used by the papers' authors to the deductive codes.

4. *Coding process and verification*: To assure internal reliability, given there was one coder, the following steps outlined by [15] were taken in addition to those suggested by [12]:

- a. The codebook was pretested against the full data set to assure ease of application and face validity. In this phase, the coder also familiarized himself with the data and added new codes, as necessary, such as *graduate attributes*, *teaching assistant*, and *experiential learning*.
- b. With a better understanding of the codes based on the pretest and familiarization process, the coder revised and prepared a new version of the codebook – composed of the codes and coding rules.
- c. The selected content was analyzed using the new codebook.
- d. An analysis was performed to compare the results from variables 4 (context/topic) and 5 (purpose/research area) and create themes (research areas) and categories (research topics).
- e. To assure validity of the results, the selected content was analyzed one more time to make sure they all complied with the new coding form. In this round, the new themes and categories were used for coding variables 4 and 5.
- f. A frequency analysis was then conducted to address the research questions, including, specifically, the main topics and areas of interest – the implicit research agenda – of the engineering education research community in Canada.

2.1. Affiliation/Institution and Number of Authors

For these variables, the affiliation (institution) was coded *in vivo*, and the number of authors was attributed a numerical value. Each institution was coded only once per paper, regardless of the number of authors with that affiliation.

2.2. Publication Stream

To characterize the publications' stream, we decided to follow the CEEA-ACEG conference guidelines. When submitting a paper to this conference, the authors must identify their work as either *Engineering Education Practice* or *Engineering Education Research*. Given that we did not have access to the category authors selected for their papers, we used the most recent definitions on the CEEA-ACEG website to assign the category to which each paper belongs. The definitions are as follows:

Engineering Education Practice: “includes accounts of innovations, experiences, and evidence-based practices in engineering education” [16];

Engineering Education Research: “includes reports of investigations, meta-analyses, and data-informed development of new methods, tools, and frameworks” [16].

2.3. Research Topics and Research Areas

The Research Topics are categories of interest, subjects or contexts that can often be associated with more than one Research Area, and can be investigated under any of these areas. In turn, the Research Areas are broader themes that group different *specific* topics, but could also be connected to the Research Topics.

For example, for one of the Research Areas identified, *Assessment*, some of the specific topics are *assessment methods* (e.g. *group*, *formative*, and *peer evaluation*) and *assessment tools* (e.g. *exams*, *portfolios* and *rubrics*). *Communication* and *educational technologies* were considered Research Topics because they could be associated with any Research Area, including *Assessment*.

Each paper was assigned only one Research Area, but they could have more than one Research Topic. It is important to note that, even though some papers could be interpreted as belonging to more than one Research Area, we decided to highlight what we understood as their primary focus.

2.4. Limitations

One of the limitations of this study is having only one coder, whose interpretation could differ from the papers' authors. Also, it is possible that the titles, keywords, and abstracts did not capture some papers' central purpose. One challenge was that authors did not always follow a similar structure or format in writing abstracts and keywords, and a few times, papers did not have an abstract or keywords. This caused a gap of information for the analysis, which required the coder to work with little information, relying only on two of the three sources – whether title and abstract, or title and keywords.

Another limitation is the scope. We know that the Canadian engineering education research community engages and publishes in other conferences and journals, and we might have missed important insights. Examining these avenues would be worthwhile future work. However, the CEEA/ACEG conference proceedings offer a good starting point for examining what is being researched by the EER community in Canada, as explained previously.

3. RESULTS AND DISCUSSION

3.1. Streams

From 138 papers in the 2019 CEEA-ACEG conference proceedings, 70% (97) were practice papers, while the remainder 30% (41) were research papers. This result confirms the practice-oriented nature of the conference, as identified by [3]. Their study showed that, between 2010 and 2017, the CEEA-ACEG conference had a small increase in the percentage of research papers – with significant variance between years – peaking at almost 40% in 2015. In their most recent year of investigation, 2017, approximately 27% of the papers were in the

research stream [3]. We hypothesize that, one of the reasons for this is that research papers are presented at the American Society of Engineering Education (ASEE) conference or in journal papers. However, this requires further investigation.

In comparison, [9] looked at 2173 articles published between 2005 and 2008 in four journals and three conferences internationally and classified 41% as research (theory) articles. If we consider only the 1385 conference articles in their study, the proportion of research articles goes down to 38% [9], showing a more practice-oriented nature of conferences than journals. Based on the 2019 findings in this study, the CEEA-ACEG community currently reports more on the practice aspect of EER than the global community investigated by [9].

3.2. Collaboration

When it comes to authorship, the EER community in Canada shows a level of collaboration similar to other communities. In 2019, the average number of authors per paper was 2.74. When investigating publications between 1998 and 2000, [17] found an average of 2.46 authors per publication in the *Journal of Engineering Education* and 1.74 in the *European Journal of Engineering Education*. Also, [9] reported an average of 2.60 authors per paper when looking at research-oriented publications in four journals and three conferences around the world from 2005 to 2008. If we consider only the number of authors of research stream papers identified in our study, we have an average of 2.56 authors per paper. It is important to note that while [9] and [17] investigated journal papers, our study focused on conference papers, and that the authorship requirements can be different for these two publication avenues.

Breaking this number down further, we found that 19.5% of the papers were individually written, 69% had between 2 and 4 authors, and 11.5% had five authors or more. That is close to what [9] found in their study, where 21% of the papers were written by one person. On the other hand, [8] found in his review of the first ten years JEE (1993-2002) that 30.8% of the papers had a single author. These numbers point to the EER community in Canada being as collaborative as other EER communities in terms of authorship.

However, the collaboration between institutions is not as predominant as the collaboration among authors. In 2019, only 8.7% (12) of the papers had authors from 2 or more institutions, showing that most of the collaboration in EER is happening within a single institution.

3.3. Affiliation/Institutions

A total of 33 Canadian and 4 international institutions were represented in the 2019 CEEA-ACEG conference. According to Engineers Canada [18], there are 44 higher education institutions with accredited engineering programs across the country. Seventy-five percent (75%)

of these institutions are represented, in different proportions, in the conference proceedings. The top 10 universities in number of publications are shown in Table 1.

Table 1: Number of papers in the 2019 CEEA-ACEG conference

Institution	Publications
University of British Columbia	21
University of Toronto	19
Queen's University	13
University of Ottawa	13
University of Calgary	12
University of Waterloo	10
York University	8
McGill University	7
University of Manitoba	7
McMaster University	6

Even though in 2019 33 Canadian institutions have publications in the conference, 56% of the papers are affiliated with the top 4. It would be interesting to investigate why certain institutions, such as the University of British Columbia (UBC) and the University of Toronto (UofT), have a significant number of publications. Together, they account for 29% of the total. Possible reasons could be Teaching Stream faculty positions at UBC and UofT, which encourage faculty to publish in SoTL (Scholarship of Teaching and Learning), and a graduate specialization in Engineering Education at UofT at both the master and doctoral level, which provides a formal pathway for graduate students in engineering education. The national engineering education conference would be a natural place for these faculty members and students to disseminate their work. Another possible reason is the size of the engineering programs, and thereby faculty, in these institutions. A more meaningful analysis might be investigating the percentage of publications in relation to the total number of engineering faculty members per institution.

3.4. The Implicit Research Agenda

We identified seven main areas of interest of the EER community in Canada. Table 2 shows these areas presented in descending order of total number of papers.

Table 2: Research areas and their respective number of papers in total, and per stream in the 2019 CEEA-ACEG conference

Research Area	Total (N=138)	Practice	Research
Teaching and Learning	71	63 (89%)	8 (11%)
Assessment	24	17 (71%)	7 (29%)

Students	23	10 (43%)	13 (57%)
Faculty	7	5 (71%)	2 (29%)
Engineering Education Discipline	6	0 (0%)	6 (100%)
Organizational	4	2 (50%)	2 (50%)
Philosophy of Engineering	3	0 (0%)	3 (100%)

If we gauge the level of interest by the number of publications, there were significant differences in interest between research areas. For example, by far, *Teaching and Learning* was the one with the most interest, accounting for more than all other areas summed together (71 vs. 67). However, if we look at the division between practice and research papers, the level of interest shifts, showing that *Students* is the area with the most interest in the research stream, even though it places third in the total. We discuss each research area in more detail below.

3.4.1. Teaching and Learning: As stated earlier, *Teaching and Learning* is the area with the most interest from the community, accounting for more than half of the publications (51.4%). This area is very practice-oriented since only 11% of its papers were in the research stream. *Teaching and Learning* involves research on instructional designs, tools, and methods, with the goal of improving students' learning. Most of the publications in this area were reports on implementing a practice, usually followed by some evaluation of either student perception or performance. These practices mainly were a course, curriculum, or intervention design, or the incorporation of an instructional method in the classroom. Project-based learning, active learning, problem-based learning, and flipped classroom were the most frequent methods. Regarding the topics being taught, design and knowledge base (both CEAB graduate attributes required for program accreditation) were the most common. Some other topics of concern were entrepreneurship, diversity, and communication (with the latter being another CEAB graduate attribute).

3.4.2. Assessment: *Assessment* is the area with the second-highest level of interest, especially in the practice stream, which accounts for 71% of its total publications. It is composed of research on assessment tools and methods to measure students' acquisition of learning outcomes. The most common specific topics within this area were self-assessment, formative assessment, group assessment, and exam formats. For the general topics, there was some research in educational technologies to improve assessment – especially automated grading. Also, for the assessed outcomes, knowledge base, design, communication, and lifelong learning, all CEAB graduate attributes, were the most frequent.

3.4.3. Students: The *Students* area is almost tied in second place regarding the total number of publications, having

just one fewer than *Assessment*. However, differently from the previous two areas, *Students* is the only one with a relative high number of publications that are research oriented (57%). This research area focuses on other aspects of students' life "beyond the classroom." Some topics of interest in this area are mental health, recruitment and retention, study behaviours, and experiences. In addition to the general student body, the most common population in these studies were female students and international students.

3.4.4. Faculty: Faculty places fourth in the number of publications (7), with a high focus on practice (71%). Papers in this area focus on faculty members' professional development, attitudes, and experiences as engineering educators. This area's topics were mostly on professional development for either instructors or teaching assistants. Other investigated issues are engineers-in-residence programs and policies to assure instructors' integrity.

3.4.5. Engineering education discipline: Although *Engineering Education Discipline* is fifth when looking at the total number of publications (6), all of them are found in the research stream. Therefore, when comparing the research stream, this area is very close to *Assessment* and *Teaching and Learning*, which have 7 and 8 papers in the research stream, respectively. As the name suggests, research in this area is on the discipline of engineering education (where this paper would be categorized). This involves the current state of the field, and the researchers and the research in engineering education. Most of the papers in this area are about the research process, including methods and rigour. Another topic present in the data was investigating the identity of engineering education researchers.

3.4.6. Organizational: *Organizational* places sixth in the number of publications, with an even split of publications between practice and research. This area involves research on institutional culture and structure, and the education system as a whole. The main topics of investigation in this area were program evaluation and accreditation. No research was conducted on institutional structure, policy, or cultural change.

3.4.7. Philosophy of Engineering: With only three papers, all of them in the research stream, *Philosophy of Engineering* is the seventh area when looking at the level of attention received from the Canadian EER community. This research area focuses on the nature of engineering and engineering knowledge. Research in this area involved engineering identity, how design knowledge is used outside of technical domains, and the importance of women in engineering.

3.5. Research Topics

While research areas target the overall purpose of the research, the research topics are about the context of the

research and help to scope and specify each study. There was no limit on the number of research topics that one paper could have: while some had as many as five, others had none. Table 3 shows the main topics of interest for the 138 papers published in CEEA-ACEG 2019 conference proceedings, and Appendix A presents the complete list of topics.

Table 3: Main research topics in the 2019 CEEA-ACEG conference Proceedings

Research Topic	Total
Design	34
Knowledge base	24
Diversity	13
Educational technology	13
Communication	9
Graduate attributes	9

Design was the most common topic, including cornerstone and capstone design projects, which shows that design is a topic of high relevance in the community. It is not surprising that design has a high level of interest, because the CEEA-ACEG conference originated from the Canadian Design Engineering Network (CDEN). Design is one of skills characteristic of engineers, and is identified as one of the 12 CEAB graduate attributes as well as being counted as an Accreditation Unit (AU) for accreditation purposes. It is also the spine of many engineering programs across Canada. As well, the former NSERC Chair in Design Engineering (discontinued in 2019, with the final chair expiring in 2023), supported 16 Design Chairs across the country, which were (and still are) a central support for funding design and engineering education and research in Canada.

Knowledge base was very present as well, which is not surprising since it comprises most of the technical knowledge in engineering and a big part of the curriculum dedicated to it. It is the first CEAB graduate attribute.

Diversity also had considerable interest from the community. More specifically, issues about inclusivity and biases were the most studied, and the population investigated was either female or international students – no other group was present. It is important to clarify that we chose to have diversity as a topic instead of an area because it was connected to most of the research areas (see Appendix A for more details).

Educational technology is another topic that received attention. It involves learning management systems, virtual reality, simulation and other technological tools to help with student learning, assessment, and even well-being. Finally, *communication* (a CEAB graduate attribute) and general mentions to *graduate attributes* overall were also

present, especially regarding assessment, teaching, and accreditation.

3.6. EER Topics and Areas in the Literature

The Research Areas identified here, and their level of interest, share differences and similarities with those found in the EER literature. For example, the Research Agenda for the New Discipline of Engineering Education [1], identifies five areas: 1) Engineering Epistemologies, 2) Engineering Learning Mechanisms, 3) Engineering Learning Systems, 4) Engineering Diversity and Inclusiveness, and 5) Engineering Assessment (see [1] for more details on each area). This research agenda has been used in the engineering education literature. For instance, there is an investigation of the “research characteristics and patterns in engineering education” in the JEE from 2000 to 2009 using these five areas to classify the papers [10]. Another example is the *Cambridge Handbook of Engineering Education Research* [19], whose editors based their organization of the book chapters on the Research Agenda detailed above.

When comparing our findings to this Research Agenda [1], “Engineering Assessment,” is equivalent to : *Assessment*, one of seven Canadian Research Areas identified in this study. “Engineering Learning Mechanisms” is included in *Teaching and Learning*, but the latter also focuses on the content delivery (teaching), not only on the development of new knowledge (learning). “Engineering Learning Systems” encompasses two of the areas identified here: *Faculty* and *Organizational*. “Engineering Diversity and Inclusiveness” was classified as a Research Topic in this study since *Diversity* connected to multiple Research Areas in the Canadian Research Agenda, as explained in the previous section. “Engineering Epistemologies” is present in the Research Area, *Philosophy of Engineering*; however, it also includes issues related to the nature of engineering and its identity. *Students* and *Engineering Education Discipline*, relevant Research Areas for the EER field in Canada, are not covered by the Research Agenda proposed by [1].

It is important to note three fundamental differences between the Research Areas in our study and those published by the Steering Committee of NEERC [1]. First, while our areas are descriptive, presenting what is being published and what researchers are currently investigating, NEERC’s areas are prescriptive, suggesting what researchers should study. It would be interesting to do a similar study such as this for the American Society for Engineering Education (ASEE) conference proceedings, to examine the similarities and differences between the prescribed and observed research agendas. Second, ours focuses on the Canadian context and NEERC’s targets the American community. We began this paper commenting on the Canadian EER evaluation, which found its beginnings in the American community, but has evolved in Canada. The purpose of this study was to identify a

Canadian Research Agenda, and the findings here demonstrate that there are differences between it and the American Research Agenda. Lastly, we investigated the year of 2019, which is 13 years after the publication of NEERC’s research agenda. EER most certainly has evolved or changed in this time, identifying new areas of interest such as interest in examining the discipline itself – *Engineering Education Discipline*. As with our first point, it would be interesting to examine the ASEE proceedings to determine if this Research Area is also reflected there; Anecdotally, we observe that they are.

Another classification for the research areas in EER was presented in [20]. Their categories were also descriptive and, even though they did not explicitly name each area, it is possible to identify them. “Curriculum development” and “student learning process,” for example, were two major areas they found in the literature, which are equivalent to what we named here as *Teaching and Learning*. They also found a high occurrence of publications on assessment, which is the Canadian *Assessment* Research Area. Another area was “diversity, recruitment and retention,” which was grouped together, but as stated, we opted to categorize *diversity* as a topic, and *recruitment and retention* as specific topics within our Research Area, *Students* (see Appendix A). What we named as *Faculty* here, was named as “engineering educators” in [20]. Their “understand desired skills” category can fall under the American Research Agenda, Engineering Epistemologies [1], since it entails understanding what skills (or knowledge) belongs to engineering, and engineers should have. In this case, it would be part of Research Area we named the *Philosophy of Engineering*. *Organizational* and *Engineering Education Discipline* are not identified by [20] in their account of what is being researched in engineering education.

Another grouping is offered by [7], who categorized engineering education research into five specific groups. In this classification, the categories “Students,” “Faculty,” “Assessment and Evaluation,” and “Courses & Programs” are very similar in both definition and names to *Students*, *Faculty*, *Assessment* and *Teaching and Learning*, in this study, respectively. Their category “Practitioners & Alumni” is not equivalent to any of our Research Areas. On the other hand, the other Research Areas identified in this study, *Philosophy of Engineering*, *Engineering Education Discipline* and *Organizational*, are not identified in the categories named in [7].

Other authors have also investigated engineering education’s research topics [8,9]. However, their work did not present research areas, instead, they classified the papers according to only research topics, which presents a challenge to compare their findings with ours directly. For example, [8] assigned 20 keywords to *JEE* publications between 1998 and 2002, and, while some (e.g. Teaching, Learning and Assessment) can be compared to the research

areas identified here, most of them (e.g. Computers, Design, Communication and Ethics) would be classified as research topics based on our methodology. Similarly, [9] identified 38 categories representing either a research topic or a context. In both these cases, because of our distinction between Research Topics and Research Areas, their categories/keywords could be considered either a Topic or an Area according to our definitions. Appendix B presents a comparison and summary of the areas and topics from studies discussed here.

After analyzing the existing literature, we found that the Research Areas proposed here are more comprehensive and recognize studies in different areas. Except for “Practitioners & Alumni” [7] – because we did not identify papers in this area in our data set – our organization includes all the areas and topics present in the literature (for a direct comparison, see Appendix B). This shows that the EER community in Canada is interested in similar areas and topics (at different levels) to those identified in other research contexts. Also, we believe that the classification of papers in Research Areas and Research Topics offer a better way to understand what is being researched in a field. While the Research Area identifies the major purpose and specific topics (e.g. flipped classroom in *Teaching and Learning*), the Research Topics offer general categories that can be researched in any area. For example, a study on diversity can be on teaching accessibility to students (*Teaching and Learning*), avoiding bias in assessment (*Assessment*), or investigating international students’ experiences (*Students*).

Given the attention and focus other authors have placed on the engineering learning process, for next steps, we will consider splitting *Teaching and Learning* into two areas: (1) *Teaching* and (2) *Learning*. For instance, if we use the definition of Engineering Learning Mechanisms [1], only two papers from the 2019 CEEA-ACEG conference would fall under *Learning* – leaving *Teaching* with 69 articles. This separation will be important as we investigate other years of CEEA-ACEG conference proceedings, as it will enable us to distinguish the research in each of these areas.

4. CONCLUSIONS & NEXT STEPS

This study analyzed the 138 papers in the 2019 CEEA-ACEG conference proceedings for publications’ stream, level of collaboration, authors’ affiliation, and research topics and areas to identify Canada’s implicit engineering education research agenda. We found that EER in Canada is very practice-oriented (70% of the papers) compared to other conferences (average of 62%), and identified an average of 2.74 authors per publication. We also identified that the collaboration between institutions was low as only 12 papers (8.7%) had authors from two or more institutions. We found that 75% (33 out of 44) of the institutions with accredited engineering programs in Canada were represented at the 2019 CEEA-ACEG conference. However, together, the top four universities

accounted for more than 56% of the total, showing a discrepancy in the level of participation between institutions. It is worth investigating the reasons for this difference.

We identified seven Research Areas: *Assessment, Teaching and Learning, Students, Faculty, Organizational, Engineering Education Discipline, Philosophy of Engineering*. However, the difference in the number of publications between areas made it clear that, at least in 2019, there were three different levels of interest:

1. *Teaching and Learning;*
2. *Assessment, Students;*
3. *Faculty, Engineering Education Discipline, Organizational, Philosophy of Engineering.*

The different levels of interest in these areas align with the conference’s practice-oriented nature. While more research-focused areas, such as *Engineering Education Discipline* and *Philosophy of Engineering*, receive less attention, *Teaching and Learning*, which is present in instructors’ daily activities, is the one with the most publications.

The Research Areas identified here are aligned with, and more encompassing than those in the literature. However, given that the literature shows a high emphasis on learning (contrary to our findings), we consider dividing *Teaching and Learning* into two categories: *Teaching* and *Learning*. We believe that, as we analyze additional years of conference proceedings in the next steps of this research, this distinction will further illuminate the Canadian EER Agenda. Also, we plan to deviate from the EER Taxonomy and rename some of the research topics according to the 12 CEAB graduate attributes, so they match the vocabulary used by our community. Regarding the methodology, we are satisfied with our research design and methods. However, we will consider adding more coders to help analyze the data and improve the reliability of the study.

Lastly, it is essential to note that we did not aim to determine the level of importance of these areas. Instead, we are gauging the community’s level of interest and attention. Even though we see all of these as essential areas for researching, we believe that determining the priorities and focus should be an open discussion in the community – and that is what we hope to foster with this research. Choosing what areas need our attention right now together is crucial to advancing engineering education in Canada.

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6. APPENDINX A: Research Topics by Research Areas

TOPICS	TOTAL	Assessment	Teaching and learning	Students	Faculty	Organizational	Engineering education discipline	Philosophy of Engineering
Design	34	4	27	1	1	0	0	1
Knowledge base	24	5	17	2	0	0	0	0
Motivation and engagement	6	0	5	1	0	0	0	0
Educational technology	13	5	5	3	0	0	0	0
Diversity	13	2	4	5	1	0	0	1
Entrepreneurship	4	0	4	0	0	0	0	0
Communication	9	3	4	1	0	1	0	0
Industry involvement	4	0	3	0	1	0	0	0
Sustainability	6	2	3	0	0	0	1	0
Teamwork	5	2	3	0	0	0	0	0
Graduate attributes	9	4	2	0	0	2	0	1
Computing skills	3	0	2	1	0	0	0	0
Problem solving	2	0	2	0	0	0	0	0
Professional skills	4	2	2	0	0	0	0	0
Arts, Humanities and Social Sciences	2	0	1	0	0	0	1	0
Critical thinking	1	0	1	0	0	0	0	0
Innovation	1	0	1	0	0	0	0	0
Problem definition	1	0	1	0	0	0	0	0
Technology literacy	1	0	1	0	0	0	0	0
Transferability	1	0	1	0	0	0	0	0
Ethics	2	1	1	0	0	0	0	0
Lifelong learning and metacognition	5	3	1	1	0	0	0	0
Socio-technical thinking	1	0	0	0	0	0	0	1
Indigenous knowledge	2	0	0	0	1	0	1	0
Creativity	1	0	0	1	0	0	0	0
Leadership	1	0	0	0	0	1	0	0
Impact of engineering	1	1	0	0	0	0	0	0
Professionalism	1	1	0	0	0	0	0	0

7. APPENDINX B: Summary of Frameworks for EER

Implicit Canadian EER Agenda	[1] Steering Committee of NEERC (2006)	[19] Borrego, M., & Bernhard, J. (2011)	[7] Whitin, K., & Sheppard, S. D. (2004)	[8] Wankat, P. C. (2004)	[9] Jesiek, B. et al. (2011).
Assessment	Engineering Assessment	Assessment	Assessment and Evaluation	Assessment	assessment; reflection
Teaching and Learning	Engineering Learning Mechanisms	Student learning process; Curriculum development	Courses & Programs	Learning; Teaching; Curriculum; Experiential/Hands On; Distance Education	learning; learning styles; curriculum; pbl; interdisciplinary; active learning; conceptual; teaching; service learning
Students		<u>Diversity, recruitment and retention</u>	Students	Retention	students; support; recruit; retain; support; recruit; retain
Faculty	Engineering Learning Systems	Engineering educators	Faculty		faculty
Organizational	Engineering Learning Systems			ABET	program evaluation
Philosophy of Engineering	Engineering Epistemologies	Understand desired skills			industry; profession
Engineering Education Discipline					
			Practitioners & Alumni		
General Topics			General Category		
Diversity	Engineering Diversity and Inclusiveness	<u>Diversity, recruitment and retention</u>		Gender/Women	diversity
Design				Design	design; capstone
Communication				Communication/Writing	communication
Knowledge Base					mathsci; engskills; graphics
Computer Skills				Computers; Internet/Web; Programming	compskills
Entrepreneurship				Entrepreneurship	business
Teamwork				Groups/Teams	collab
Labs				Laboratory	labs
Educational Technology					ed.tech
Ethics				Ethics	socpolorg
Intercultural Competence				International/Global	global
Sustainability					envsust
Professional Skills					genskills; competencies
Graduate					graduate
K12					k12
First Year				First Year	first year