ENGINEERING EDUCATION: ARE EFFORTS IN SOTL REACHING THE ENGINEERING CLASSROOM?

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ABSTRACT

If you were to walk into almost any engineering classroom today it would be difficult for you to differentiate it from one in 2000, 1980 or even 1960. The technology and tools may be different, but the delivery largely remains teacher-directed and lecture-based. While the Scholarship of Teaching and Learning (SoTL) is widely supported at most post-secondary institutions, there is little evidence that this scholarly work is reaching the engineering classroom. Similar work in Discipline-Based Education Research (DBER) also appears to be going unimplemented. This descriptive study examines the level to which engineering faculty at Canadian institutions are accessing and applying the findings of SoTL and DBER work within their classrooms.

KEYWORDS

SoTL, engineering education, Discipline-Based Education Research (DBER), evidence-based teaching, Standards: 7, 8, 10, 11

INTRODUCTION

Most undergraduate engineering students experience learning in exactly the same way as did generations of graduates before them. Even with evidence-based methodologies, tools, and technologies, the traditional, teacher-centered, lecture-based classroom still prevails. At the same time, institutional teaching and learning centres support both the scholarship of teaching and learning and the practicalities of day-to-day teaching.

Many researchers have tried to understand this dichotomy between theory and practice. There are myriad opportunities for instructors to learn about and implement the findings of both the Scholarship of Teaching and Learning (SoTL) and Discipline-Based Education Research (DBER), but there is little evidence that this scholarly work is making its way into engineering classrooms. This paper reports the findings of a national survey that measures the level to which current engineering faculty at Canadian institutions are accessing and applying the findings of SoTL and DBER work within their classrooms.

BACKGROUND

Engineering in Canada pre-dates its 1867 confederation. Engineers Canada, the national organization of the provincial and territorial associations that regulates the practice of engineering in Canada, defines the “practice of engineering” as “any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment” (*National guideline on the practice of engineering in Canada*, 2012). Early civilian and military engineering helped establish the country’s transportation, fortification, and infrastructure systems. It took about 30 years from the creation of the first engineering organization in 1886, until all Canadian provinces at the time had enacted Professional Engineering Acts to regulate the profession. At the time this included civil, mechanical, chemical, electrical, and mining engineers (Devita, 2012). Engineers Canada is now comprised of 12 engineering regulators that license the country's 290,000 practicing engineers in both traditional and non-traditional disciplines as diverse as aerospace, geomatics, industrial, naval, petroleum, and software engineering.

Engineering Education

While engineering practice itself was integral to the colonization of Canada, attempts at formalizing engineering education did not get underway until the 1850s. The first engineering course, two and a half months in duration, was offered at King’s College in New Brunswick (now University of New Brunswick) in 1854 with 26 students enrolled. By the turn of the 20th century there were six engineering schools across the country offering programs in civil, electrical, mining, and mechanical (Morris, 1986). Now, almost two decades into the 21st century, there are 43 schools offering 281 accredited engineering programs.

Accreditation of Canadian engineering schools began in 1965. This process, undertaken by the Canadian Engineering Accreditation Board (CEAB), a committee of Engineers Canada, ensures that graduates of engineering programs meet the high standards necessary to become licensed professional engineers. Initially an accreditation review examined the depth and breadth of the science, mathematics, engineering science, engineering design and complementary studies within a program. In 2015 this was expanded to include an assessment of 12 graduate attributes encompassing the professional body of knowledge (knowledge base, problem analysis, investigation, design, and engineering tools), employability skills (individual and team work, communication skills, life-long learning), and professional responsibilities (impact on society, ethics and equality, economics and project management, and professionalism) required of a professional engineer (Nelson, 2014). Programs are also expected to demonstrate ongoing quality through implementation of a continual improvement plan.

Graduate attributes have engineering educators looking for ways to make undergraduate engineering programs more authentic and student-centered, and create an environment where students are actively engaged in, and accountable for, a deeper form of learning. These efforts are happening at all levels from international, to institutional, to individual.

Movements such as CDIO (Conceive-Design-Implement-Operate) suggest that conceptual-change instruction, where learning happens through a series of authentic, integrated learning experiences some of which are experiential, will teach both the body of knowledge and skills required to be a professional engineer (Crawley, Malmqvist, Östlund, & Brodeur, 2014).

Learning experiences like this challenge students to construct their own knowledge and confront their misconceptions. Most Canadian engineering programs are increasing the number of design-based project courses to help students recognize the integrative and cross-disciplinary nature of engineering projects. Other programs include project- and/or problem-based learning as part of their curriculum (Woods, 1996; Nelson, 2014), and some have fully transitioned to project-based and problem-based learning (Gonzalez-Rubio, Khoumsi, Dubois, & Trovao, 2016). These are all steps toward a more authentic undergraduate engineering experience, but as the CDIO vision suggests, reform in engineering education requires the review of four intertwined areas: the overall curriculum and course content, the learning environment, the way content is taught, and assessment and evaluation of the program outcomes (Crawley et al., 2014). One of the biggest challenges in this effort is to overcome the situational barriers and constraints that affect whether instructors can effectively implement the findings of research in engineering education (Henderson & Dancy, 2007).

Engineering Education Research (EER)

A review of the major shifts in engineering education was commissioned by the Institute for Electrical and Electronic Engineers (IEEE) on its 100th anniversary (Froyd, Wankat, & Smith, 2012). It reported five shifts: (1) from a hands-on, practical approach to an engineering science and analytical emphasis, (2) to outcomes-based education and accreditation, (3) toward engineering design, (4) to applying education, learning, and social-behavioral sciences research, and (5) to the integration of technology in education. The first two shifts have occurred, while the remaining three are still in progress. Of interest to this paper is the fourth shift, in particular the application of interdisciplinary research methods to engineering education.

Although formalized research in engineering education is still considered to be in its infancy (Borrego, Foster, & Froyd, 2014), engineering educators have always been committed to improving instruction at the classroom level. Formed in 1893, the Society for the Promotion of Engineering Education (SPEE) was the first official organization in North America to dedicate itself to the noble yet sometimes difficult task of promoting high quality and effecting change in engineering education (Reynolds & Seely, 1993). In 1946 this organization became the American Society for Engineering Education (ASEE) which is still committed to furthering education in engineering and engineering technology. In 2003 its quarterly scholarly publication, the Journal of Engineering Education (JEE), was the first journal dedicated solely to the publication of peer-reviewed research in engineering education.

Similar organizations dedicated to engineering education research developed around the world, including in Canada. The Canadian Engineering Education Association (CEEA) formed in 2010 integrating the efforts of the Canadian Design Engineering Network (CDEN) and the Canadian Congress on Engineering Education (C2E2) (Yellowley, Venter, & Salustri, 2001). Its mission is to “enhance the competence and relevance of graduates from Canadian Engineering schools through continuous improvement in engineering education and design education” (CEEA, 2018). While CEEA does not currently have a publication to share the findings reported at its annual conference, as of 2018 it will separate its proceedings into those that are reporting peer-reviewed, research-informed findings, and those that report general practices such as innovations and experiences in the classroom.

Engineering education research tends to be published in two types of journals: those dedicated to SoTL, and those dedicated to DBER.

Scholarship of Teaching and Learning (SoTL)

The Scholarship of Teaching was first introduced by Ernest Boyer in 1990 (Boyer, 1990) to help bring focus to the importance of teaching as part of the appointment, promotion, and tenure of academic staff. Over the years this evolved into the Scholarship of Teaching and Learning as researchers emphasized that their work focused on student learning. SoTL studies are typically descriptive and focus on innovation in one's own higher education classroom (Dolan et al., 2017). Its five principles of good practice clarify that SoTL research is (1) inquiry into student learning, (2) grounded in context, (3) methodologically sound, (4) conducted in partnership with students, and (5) appropriately public (Felten, 2013).

SoTL efforts vary across Canada. While disciplinary research is funded nationally, pedagogical research falls under the jurisdiction of provincial governments and funding can be very difficult to acquire. Many institutions have established strong SoTL programs to support their faculty, and graduate students appreciate and participate in SoTL research. The Society for Teaching and Learning in Higher Education (STLHE) identified SoTL as the first of its four pillars or strategic directions, and in 2009 established a partnership with the International Society for the Scholarship of Teaching and Learning (ISSoTL) to acknowledge their common goals around SoTL. In 2010 STLHE launched the Canadian Journal for the Scholarship of Teaching and Learning (CJ SoTL), the first Canadian open access, peer-reviewed national venue for transdisciplinary SoTL research (Simmons & Poole, 2016).

Provincial and institutional studies have been done to measure the involvement of university faculty in SoTL activities. Instructors reported that their teaching knowledge came mostly through practice, learning by doing, or consulting with colleagues. They identified that there is disparity between merits of research and teaching, and that traditional research pays off in status and reputation. Most of those who reported doing classroom research indicated they used the results to modify their own teaching. Many of these instructors who were doing SoTL work felt their efforts had little or no visibility to their colleagues unless it was published in a high impact peer-reviewed venue (Britnell et al., 2010; Wuetherick, Yu, & Greer, 2016).

Discipline-Based Education Research (DBER)

Discipline-Based Education Research is a term used primarily by post-secondary educators in Science, Technology, Engineering, and Mathematics (STEM). It is a form of scholarship of teaching and learning that requires deep knowledge of the disciplinary content and its practices, in addition to the expertise needed to conduct education research (Singer, Neilsen, & Schweingruber, 2012). DBER is typically conducted in one of the following areas: engineering epistemologies (ways of thinking and knowing within the discipline), learning mechanisms (developing knowledge and competencies), learning systems (culture, infrastructure, and epistemology of educators), diversity and inclusivity, assessment, or design.

Initial DBER efforts typically involve identifying incorrect understandings and misconceptions, and identifying those that are most difficult to change. It then extends to the identification of instructional strategies or techniques that help students move beyond the troublesome concepts and ultimately improved learning.

In Canada STLHE recognizes DBER and its discipline-specific emphasis as a parallel form of educational research and suggests that each community has much to offer to the other. The findings of engineering-related DBER are typically presented and published through its own

Engineering Education Research (EER) organizations such as the American Society for Engineering Education (ASEE) and CEEA.

The differences between doing discipline-specific research and EER present distinctive challenges for STEM educators moving into the world of SoTL or DBER. First they must be prepared to engage with the literature both within and beyond their discipline. They must learn and use a new vernacular, and move from a teacher-centered focus where they consider the importance of their teaching to a more student-centered approach where the focus is on student learning. They must use different research methods, analyze their data in different ways, present to a different audience, and finally accept that EER, as a form of SoTL, requires one to consider theoretical frameworks and accept applicability as a goal of rigorous research. (Krefting, 1991; Streveler, Borrego, & Smith, 2007; Tierney, 2017).

Dissemination of SoTL and DBER

There are four levels of rigor at which an instructor can engage in education-related inquiry: excellent teaching, scholarly teaching, scholarship of teaching, and rigorous research (Borrego, 2007). Ideally, every instructor teaching in an undergraduate engineering program is involved in at least the first level which means bringing excellent content and evidence-based instructional strategies to the classroom. Unfortunately the research shows that a gap exists between the research and the classroom (Henderson & Dancy, 2007) (Singer et al., 2012) (Froyd, Borrego, Cutler, Henderson, & Prince, 2013) (McLaren & Kenny, 2015) (Dancy, Henderson, & Turpen, 2016).

The results are shared with educators through conferences, workshops, and talks, but the actual Research-Based Instructional Strategies (RBIS) are not making their way into the day to day classroom. Some instructors experiment with RBIS but find that they don’t work in their particular environment. Some of the more commonly identified reasons for discontinuing or not attempting to integrate RBIS are institutional expectations around the balance of research, teaching, and service, lack of departmental or institutional support, and situational constraints and barriers such as student resistance, available time to cover content, and increased preparation time.

Bridging this gap between research and practice requires four key things: (1) the work must be consistent with research on motivating adult learners, (2) effort must be placed on changing faculty conceptions about teaching and learning, (3) the cultural and organizational norms must be recognized as part of a strategic move toward scholarly teaching and/or rigorous EER, and (4) action must be taken to address the barriers to change in teaching practice (Singer et al., 2012).

In order to establish a starting point for change, this research examines the level to which engineering faculty teaching in accredited engineering programs across Canadian institutions are accessing and applying the findings of SoTL and DBER work within their classrooms.

PROCESS

Early in 2018 engineering educators were asked to complete an online survey about the current state of undergraduate engineering education in Canada. This survey explored the types and balance of research, teaching, and service engineering educators do, the characteristics of the teaching and learning environment, and perceptions about the learners sitting in our classrooms.

A subset of this survey explored the instructors' engagement with SoTL and/or DBER looking for four key facets: (1) how informed they are about SoTL/DBER, (2) how important evidence-based teaching is in their own practice, (3) how interested they are in applying RBIS in their classrooms, and (4) how involved they are in doing SoTL/DBER research. This portion of the broader survey is used for this research.

Methodology

3376 participants were invited by e-mail to complete an online survey entitled A Snapshot of Canadian Engineering Education. Some institutions provided the researchers with a mailing list of their faculty, others were contacted directly via the e-mail posted on their departmental web site, and a third group were contacted through their on-campus member of GANet, an online network of engineering faculty and staff involved in the engineering accreditation process. There were no incentives provided for instructors to complete the survey.

The survey, modeled after the Higher Education Quality Council of Ontario (HEQCO) survey on faculty engagement in teaching development activities (Britnell et al., 2010), collected basic demographic data including the name of the institution, and the number of years they had been teaching. It had two major sections: (1) Institutional Expectations that examined the balance and types of service, research, and teaching, and (2) Undergraduate Engineering Education that captures what the current undergraduate learning experience is like.

Data Analysis

224 of the 3376 engineering educators (6.6%) participated in this research study. There was representation from 74.4% of the institutions that offer accredited engineering programs. 17.9% were new instructors who had been teaching fewer than five years, 42.9% were mid-career faculty who had been teaching between five and 15 years, and the remaining 39.3% were seasoned instructors with more than 15 years.

There is a possibility that the findings of this survey have a bias associated with non-response. Those who chose to complete the survey may have different views from those who did not. This may limit the generality of the results of this study (Sax, Gilmartin, & Bryant, 2003; Adams & Lawrence, 2015). It is also not known to what degree respondents were encouraged to participate by their institution's administration or what other factors may have contributed to their response or non-response. As a result, the following findings should be considered with caution.

Five of the 28 variables available in the full data set were analyzed to examine the instructors' engagement with EER. Each of these five are related to the instructors' teaching practice: (1) how they maintain currency, (2) frequency of participation in teaching related professional development activities, (3) how often they reference SoTL or DBER resources, (4) participation in DBER or SoTL research, and (5) willingness to use or access a digital resource that delivers short concise abstracts of engineering education related research findings with associated application notes and examples.

Maintaining Currency

Question 15 asked participants to indicate whether or not they used 10 different ways of staying current in their teaching practice. The percentage of instructors who indicated using each of the methods is shown in Figure 1.

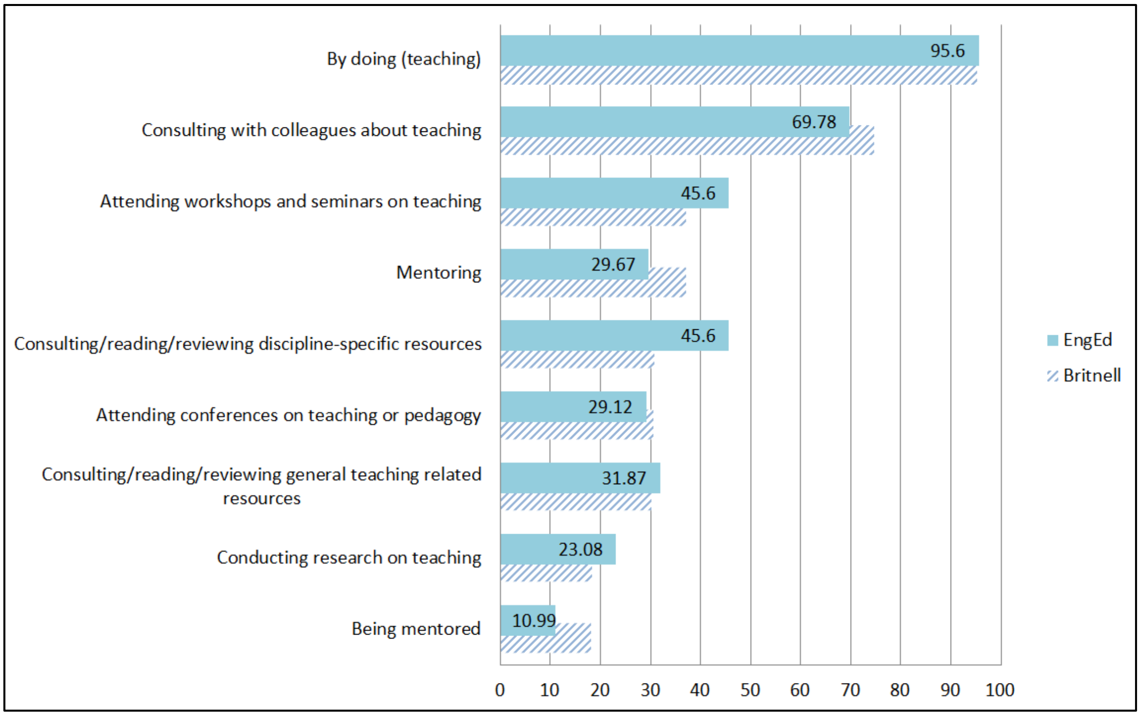

Figure 1: Method for Staying Current in Teaching

The most commonly used technique that educators use to stay current is learning by doing (95.6%). This is followed by consulting with colleagues (69.8%). The least used techniques are conducting research on teaching (23.1%) and being mentored (11.0%). The three items specifically related to SoTL and DBER indicate that 45.6% are interested in learning about teaching and learning by attending workshops or seminars, that the teaching practice of 31.9% of the instructors is informed by published education-related research, and that 23.1% are involved in DBER or SoTL research.

The most noticeable differences between these results and those of the 2010 Ontario study of post-secondary educators (Britnell et al., 2010) are in the almost 15% increase in the percentage of instructors who are informing their teaching practice by consulting, reading, and/or reviewing discipline-specific resources, the 8.4% increase in the percentage of instructors attending workshops and seminars on teaching, and the just over 7% decrease in both mentoring and being mentored.

Participation in Teaching-Related Professional Development

Question 18 asked participants to indicate whether or not they participated in five different forms of teaching-related professional development (PD). The percentage of instructors that indicated participating in each form of PD is shown in Figure 2. The majority of instructors (62.6%) are discussing teaching and learning with their colleagues at least monthly and are doing critical self-reflection at least once a month (53.1%). Only a tenth (10.1%) indicated that they regularly use the services offered by their teaching and learning centre.

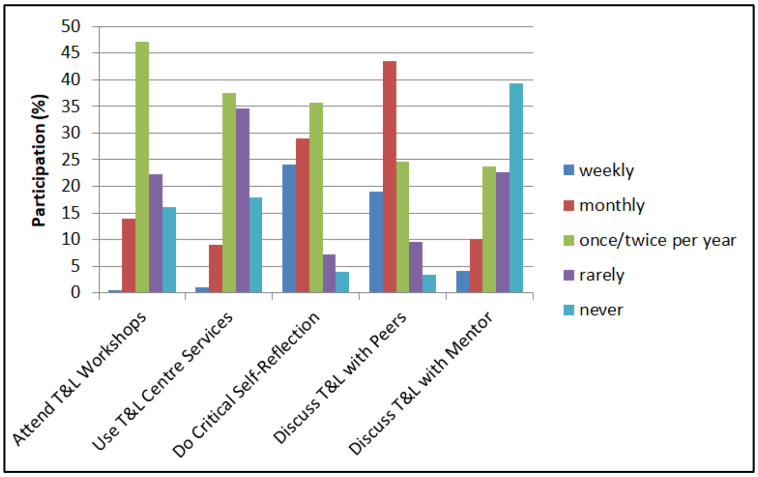

Figure 2: Participation in teaching-related professional development

These results show a decrease in PD activities compared to the 2010 Ontario study of post-secondary educators (Britnell et al., 2010) where 73.5% instructors indicated they discussed teaching and learning with their colleagues at least monthly and (60.9%) did critical self-reflection at least once a month.

Use of SoTL and/or DBER Resources

Question 21 asked participants to indicate how often they read general and discipline-specific literature related to teaching. Figure 3 shows that the minority of instructors (46.2%) are infrequent or non-readers of general literature related to teaching and 42.5% are infrequent or non-readers of discipline-specific literature related to teaching.

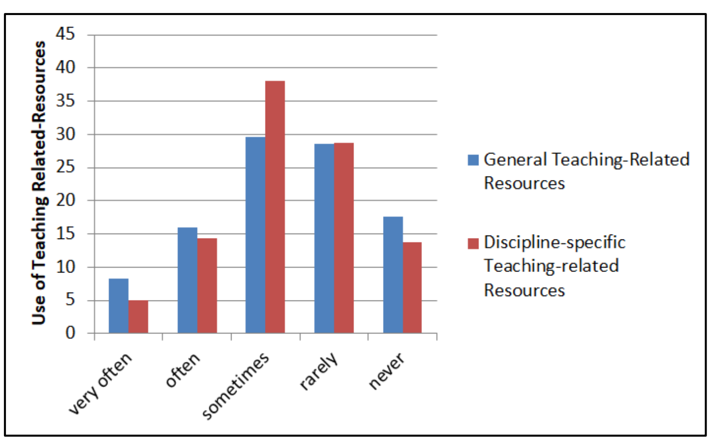

Figure 3 - Use of Teaching-Related Resources

These results show an improvement in how often instructors use teaching-related resources compared to the 2010 Ontario study of post-secondary educators (Britnell et al., 2010) where 65.3% were infrequent or non-readers of general literature related to teaching and (63.1%) were infrequent or non-readers of discipline-specific literature related to teaching.

Participation in DBER or SoTL Research

Question 24 asked participants to indicate whether or not they had done any formal or informal research related to the teaching and/or learning in their classroom. Figure 4 shows the types of classroom-related research reported by the 32.8% of overall participants who indicated they had done this type of formal or informal research. 36.1% of this research activity had research ethics board approval. The most commonly reported types were associated with general aspect of teaching and learning such as surveys of student satisfaction, and student behaviour (36.1%). The majority of these research findings were used for effecting change in the instructors' own practice (52.5%). 37.7% of the findings were presented at conferences and 9.8% published in journals. 81.0% of instructors reported that these findings did results in some level of change to their classroom practices.

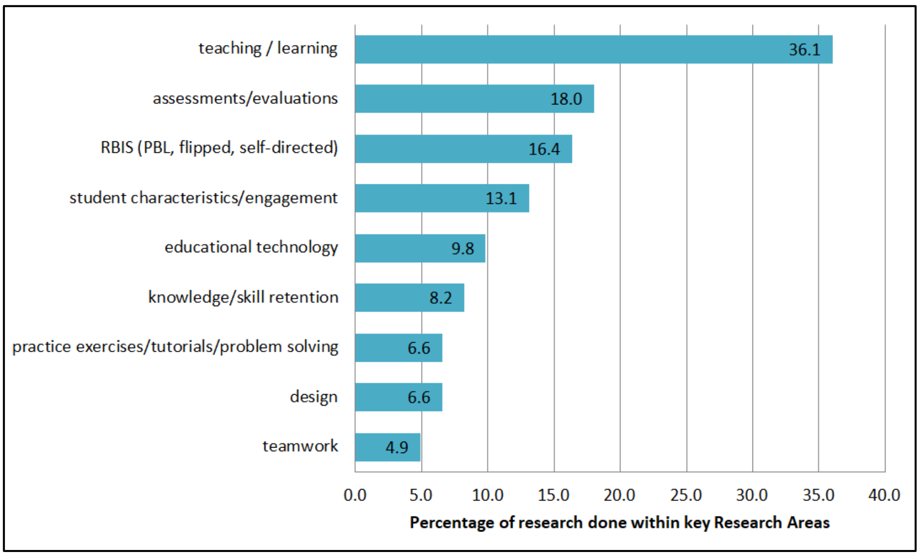

Figure 4: Types of Classroom-related Research done by Canadian Engineering Educators

Willingness to Receive SoTL and DBER Resources

Question 27 asked participants to indicate how likely they would be to use or access a digital resource that delivers short concise abstracts of engineering education related research findings with associated application notes and examples. Figure 5 shows that the majority of instructors (59.4%) are likely to access or use this type of resource.

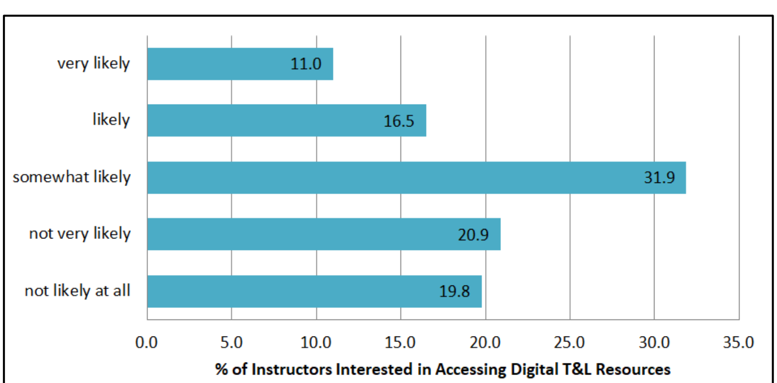

Figure 5: Willingness to Receive SoTL and DBER Resources

RESULTS

Grouping different aspects of the analyzed data helps identify just how engaged instructors are with SoTL and/or DBER in four key area: (1) how informed they are about SoTL/DBER, (2) how important good teaching is their own practice, (3) how interested they are in applying RBIS in their classrooms, and (4) how involved they are in doing SoTL/DBER research. Table 1 shows the questions and results used to calculate a strength factor for each of the four key areas. This strength factor is calculated as the mean of the means for each of the applicable measures of EER engagement. Measures based on percentages of a subset of data are reported, but not included in the strength factor.

Table 1: Calculation of Strength Factor for Instructor Engagement with SoTL and DEBR

Informed about SoTL and DBER

	Maintaining Currency			PD		Use of Resources		Participation		
Questions	15c	15f	15g	18a	18b	21a	21b	24a	24d	
	workshops	teaching-related conferences	research	workshops	TLC services	general teaching resources	discipline-specific teaching resources	own research	ethics?	
% participation	45.6	29.1	31.9	61.7	47.5	53.8	57.5	32.8	36.1	STRENGTH FACTOR
Mean	35.5			54.6		55.6		32.8	not applicable*	45
Std Deviation	8.8			10.0		2.6				

* percentage of a subset of data

Importance of evidence-based teaching

	Maintaining Currency			PD				Use of Resources		Participation	Willingness	
Questions	15b	15c	15f	18a	18b	18d	18e	21a	21b	24a	27	
	colleagues	workshops	teaching-related conferences	workshops	TLC services	colleagues	mentor	general teaching resources	discipline-specific teaching resources	own research	easy access to digital resource	
% participation	69.8	45.6	29.1	61.7	47.5	87.2	38.1	53.8	57.5	32.8	59.3	STRENGTH FACTOR
Mean	48.2			58.6				55.6		32.8	59.3	51
Std Deviation	20.5			21.4				2.6				

Interest in applying SoTL and DBER findings in own teaching practice

	Maintaining Currency			PD		Use of Resources		Participation	Willingness	
Questions	15c	15f	15g	18a	18b	21a	21b	24a	27	
	workshops	teaching-related conferences	research	workshops	TLC services	general teaching resources	discipline-specific teaching resources	own research	easy access to digital resource	
% participation	45.6	29.1	31.9	61.7	47.5	53.8	57.5	32.8	59.3	STRENGTH FACTOR
Mean	35.5			54.6		55.6		32.8	59.3	45
Std Deviation	8.8			10.0		2.6				

Involvement with SoTL and DBER

	Participation				
Questions	24a	24b	24c	24d	
	own research	caused change?	shared with community?	ethics?	
% participation	32.8	81.0	47.5	36.1	STRENGTH FACTOR
Mean	32.8	not applicable*			33
Std Deviation					

Informed about SoTL and DBER

Table 1 shows that engineering instructors across Canada are reasonably well informed about SoTL and DBER, as well as ways the research can improve their teaching practice. While their overall use of education-related research to maintain currency in their teaching is quite low (M = 35.5 SD = 8.8), they are participating in professional development activities (M = 54.6 SD = 10.0) and accessing teaching resources (M = 55.6, SD = 2.6) that can help inform their teaching practice. 32.8% indicate they are already conducting education-related research, although only a small portion of that research has received approval from an ethics board (36.1%). A middling strength factor of 45 indicates a reasonable level of engagement with SoTL and DBER at the information level, but there is opportunity for improvement.

Importance of evidence-based teaching in own practice

Engineering instructors across Canada seem to recognize the value of evidence-based teaching in their own practice. Discussing teaching and learning related issues and challenges with their colleagues, and attending teaching-related workshops and conferences (*M* = 48.2 *SD* = 20.5) show an interest in quality teaching. Their level of participation in professional development activities including those offered by their institution's teaching and learning centre (*M* = 58.6 *SD* = 21.4) and access of teaching resources (*M* = 55.6, *SD* = 2.6) indicates that about half recognize how the findings of teaching-related research can help guide their teaching practice. 32.8% indicate they are already conducting education-related research, and 59.3% report they would willingly access a digital resource that delivers, evidence-based EER that included abstracts, application notes, and examples. A moderate strength factor of 51 indicates a reasonable understanding of the importance of SoTL and DBER, but that there is opportunity for improvement.

Interest in applying SoTL and DBER findings in own teaching practice

Engineering instructors across Canada seem reluctant to apply SoTL and DBER findings in their own teaching practice. While their overall use of education-related research to maintain currency in their teaching is quite low (*M* = 35.5 *SD* = 8.8), they are participating in professional development activities (*M* = 54.6 *SD* = 10.0) and accessing teaching resources (*M* = 55.6, *SD* = 2.6) that can help generate interest in transforming what happens in their classrooms. 32.8% indicate they are already conducting education-related research in order to improve the learning experience in their own classrooms. 59.3% report they would access a digital resource that delivers short concise abstracts of engineering education related research findings with associated application notes and examples on a need-to-know basis. A slightly lower strength factor of 45 highlights this juxtaposition between the instructor's low usage of EER and their willingness to explore the literature if presented in a more tangible, practical way.

Involvement with SoTL and DBER

The percentage of engineering instructors in Canada who are involved in SoTL and DBER research is quite low (32.8%), and only a small portion of that research has received ethics approval (36.1%). These instructors are using their findings to make changes in their own classrooms (81.0%) but fewer than half are making their work public (47.5%). A low strength factor of 33 indicates this reluctance to conduct rigorous EER. If institutions, departments, and programs value this type of research it may not be obvious to their instructors.

DISCUSSION

The results of this study indicate that educators in accredited engineering programs across Canada are moderately engaged in the scholarship of teaching and learning and/or discipline-specific education research. These instructors are reasonably well informed about what SoTL and DBER are, and are aware of ways in which the findings of this research can improve their teaching. They seem to recognize the value of evidence-based teaching, but seem reluctant to actually integrate it into their own practices. This concurs with the findings of studies that show evidence-based instructional strategies are making it into few classrooms. Commonly identified barriers include, but are not limited to, workload, time, institutional reward system, content coverage, student attitude, and availability of resources

(Kaupp et al., 2015)(Henderson & Dancy, 2007)(Litzinger, Lattuca, Hadgraft, & Newstetter, 2011). Finding ways to eliminate or reduce these barriers could help facilitate the move toward evidence-based teaching in engineering classrooms.

This study found the percentage of instructors conducting any form of engineering education research to be quite low, with only a small portion of those doing rigorous research. This concurs with a Canadian engineering research review that shows that while less than 30% of the papers are theory-based, there is a trend toward more rigorous research (Brennan et al., 2018). In 2017 the Canadian Engineering Education Association (CEEA) established an annual Institute for Engineering Education Research (IER). The one day workshop includes the essential elements required to design and conduct ethical qualitative, quantitative, or mixed methods education-based research.

Together, these findings suggest that there is opportunity to improve engineering instructors' overall engagement with engineering education research, and that many educators are willing to implement the findings of SoTL and DBER in their classes if it can be made available to them in a tangible and practical way.

FUTURE WORK

Further studies will explore the opportunities to improve instructor engagement with EER. First would be to examine the distribution of effort specified by institutions, departments, and programs for the appointment, promotion and tenure for both professorial rank (i.e. research and teaching) and instructor rank (i.e. teaching) faculty. This could help determine the level to which they emphasize and officially recognize the importance that EER plays in the ongoing success of undergraduate engineering programs. Without this recognition it is unlikely that instructors will engage in EER beyond the current level. Research will also be done to more clearly define the barriers faced by Canadian engineering educators as they integrate EER findings into their classrooms.

In addition, an annual review of CEEA papers will help determine whether the IER affects the number Canadian publications based on rigorous engineering education research. This could be used as one indicator of the level of EER engagement within the Canadian engineering education community. It would also be interesting to compare countries with a longer history of EER (e.g. United States, Australia) with those that are relative newcomers (e.g. Canada).

Further study will also explore the types and forms of EER literature that faculty would consider most helpful should they choose to integrate the findings of SoTL and DBER into their teaching practice and/or conduct rigorous engineering education research.

ACKNOWLEDGEMENTS

This research study is funded by the National Sciences and Engineering Research Council of Canada (NSERC) and approved by the University of Calgary Conjoint Faculties Ethics Board. Special thanks to the engineering educators who took the time to complete this survey, and the peer reviewers for their time and invaluable feedback.

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