Developing a Primer for First-Year Engineering Educators

Abstract

This Work-in-Progress paper lays the foundation for a primer for first-year engineering educators. A first-year engineering education primer is an introductory document on the fundamentals of research related to teaching, mentoring, and coordinating the first-year engineering experience. The motivations for the First-Year Programs Division to develop this primer is the transfer of research outcomes and facilitation of informed decision making for practicing professionals. Primers are often developed in fields of study to assist with the dissemination of evidence-based best practices. New engineering educators, administrators, and advisors who have little experience with first-year engineering programs or education research can use the empirical data from the primer to effectively transfer research findings into the classroom and student experience. This work-in-progress paper documents preliminary research to determine the scope of the thematic topics to be included in the primer. The preliminary research is bounded by the American Society for Engineering Education First-Year Programs Division and First-Year Engineering Experience conference sessions, best papers, and call for papers. The topics generated in this study may also be used to refine future calls for papers and session themes. In the future, a committee or workshop could be used to refine these findings.

Introduction

This study examines the American Society for Engineering Education (ASEE) First-Year Programs Division (FPD) and First-Year Engineering Experience (FYEE) conferences to determine the most common topics for first-year engineering research. Original results are presented on the frequency of session topics, appearance of topics in the call for papers, and the topics of best paper awards from each year. These topics are recommended sections of the primer, such as design, teamwork, diversity, retention, and assessment. The findings of this paper can assist with the creation of a call for papers and session topics for future conferences. Future recommendations for this study are to establish a team of researchers who will work to compile content for the first-year engineering education primer.

The need for creating a primer is to introduce practitioners to the field for first-year engineering research, which may help to grow the community and ensure that evidence-based practice principles are followed. The format and intended audience of the primer can reduce the barrier to entry to education research. As the body of knowledge around first-year engineering grows, creating an elementary introduction increases the access and dissemination of research findings. The main motivation for producing a primer is to collect content over decades of research on the first-year engineering experience.

Literature Review

An example primer is *A Policy Maker's Primer on Education Research*, which provides a precedence for creating a primer when a field is significantly advanced (1). These types of primers can be used to help to make decisions by practitioners; for education, practitioners include administrators, educators, advisors, and researchers. In order to help with recruitment

and outreach for ASEE, primers can help assist novices with familiarizing themselves with the field. Not only does the primer summarize the research, but it explains how to interpret research output and apply it to practice.

This paper adapts a model introduced by Weiner et al. (2018) to first-year engineering education research at the ASEE and FYEE annual conferences (2). This study did not apply a thorough systematic literature review defined by Borrego et al. (2014), and instead focuses on the thematic topics for conference sessions and call for papers (3). This paper applies the second-cycle qualitative analysis prescribed by Saldaña (2015) to identify a list of themes for all sessions, best papers, and call for paper topics (4). After the initial coding a second cycle was used to revise the thematic grouping into categorical topics. Further development of the primer should implement recommendation from Borrego et al. (2014) for performing a thorough review of relevant literature (3).

This paper also reviewed the Reid et al. (2018) first-year engineering taxonomy (5). The main topics in the taxonomy were cross-referenced to help establish the thematic topics for the primer. The primer differs from the taxonomy because the primer is about the collection and dissemination of first-year engineering education research whereas the taxonomy is an outline of common topics covered in first-year engineering courses. An overview of the taxonomy should be the first section of the first-year engineering education primer.

Methods

The selection of studies used for this analysis was bounded by publically available session topics for ASEE FPD and FYEE conferences, call for papers for ASEE FPD and FYEE conferences, and ASEE FPD best papers. Publically available resources for finding the studies include the ASEE Papers on Engineering Education Repository (PEER) database, ASEE Annual Conference Session Locator, ASEE Annual Conference website, and FYEE websites. The PEER database includes data from ASEE conference papers since 1996, but only identifies papers by division since 2006. PEER also includes FYEE papers since 2017. The ASEE Annual Conference Session Locator was used to retrieve the ASEE FPD sessions from 2011-2018, while the FYEE sessions were pulled from the FYEE websites. PEER was used to collect session topics from ASEE FPD 2006-2010. Best papers were compiled from the ASEE Annual Conference Session Locator. Call for papers were retrieved from ASEE Annual Conference website and FYEE websites. These call for papers are documented in the Appendices including the major revisions that took place for FYEE in 2015. No major changes were evident in the publically available ASEE FPD conference call for papers.

The years that were publically available for ASEE papers were 2006-2018, while only 2012-2018 are available for FYEE. Repositories for the call for papers exist for ASEE FPD from 2016-2019, and 2012-2019 for FYEE. Best papers session only existed as ASEE FPD sessions from 2015-2018. All of the data compiled for this study can be found in an Excel file here: https://tinyurl.com/fpd-primer-initial-themes.

Table 1 lists the thematic topics identified by the second-cycle qualitative analysis. This list includes all topics in prior ASEE FPD and FYEE call for papers with the addition of

common session topics that have appeared at recent conferences. For most topics in Table 1 a representative paper from the ASEE FPD best papers or conferences are referenced. These thematic topics were used for the data analysis completed in the next section.

Table 1: Thematic Topics for a First-Year Engineering Education Primer

Thematic Topics			
1. Research (General)			
Theme Categories			
Pedagogy	**Cornerstone**	**Enrollment**	**Resources**
2. Innovation	6. Projects (8)	10. Diversity (12)	14. Student Outcomes (15)
3. Assessment (6)	7. Design (9)	11. Retention (13)	15. Classroom Strategies (16)
4. Curriculum (5)	8. Problem-Based (10)	12. K-12 Transition (14)	16. Learning Technology (17)
5. Experiential (7)	9. Teamwork (11)	13. Recruitment	17. Space (18)

Analysis

The frequency of topics was collected by ASEE FPD session topics, FYEE session topics, ASEE FPD and FYEE session topics combined, and ASEE FPD best papers. Histograms of the frequency distribution were produced by limiting to the top ten most common themes, including ties. In each chart the number of sessions related to a theme increases from left to right.

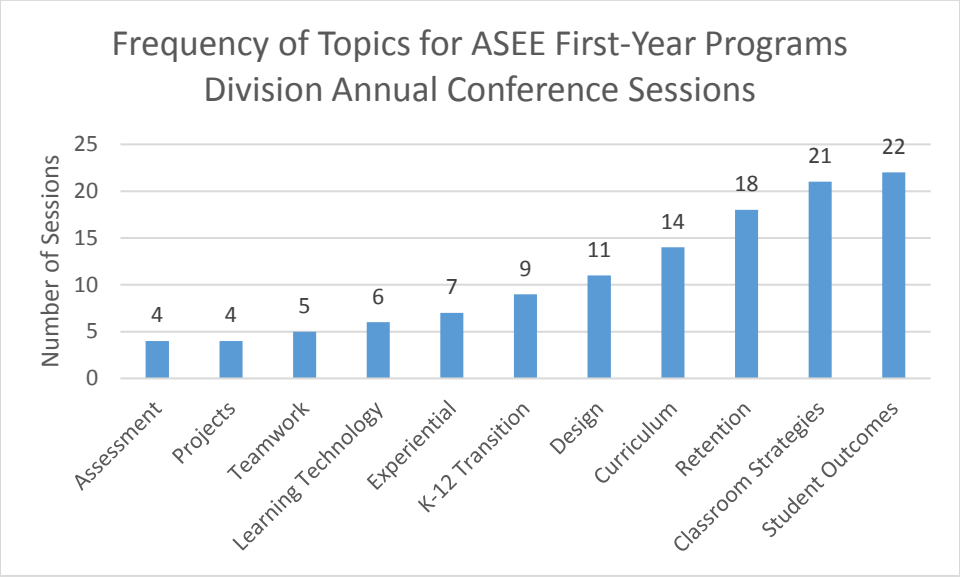

Figure 1: Number of ASEE FPD Sessions Related to First-Year Engineering Education Themes

Several themes emerge when comparing ASEE session topics in Figure 1 and FYEE session topics in Figure 2. Student outcomes and classroom strategies are the most common

session topics. Both of these themes have the potential to be broken down into subcategories. Retention, curriculum development, design, K-12 transition, and experiential learning were also frequently used. The distribution of session topics at ASEE FPD appears similar to FYEE.

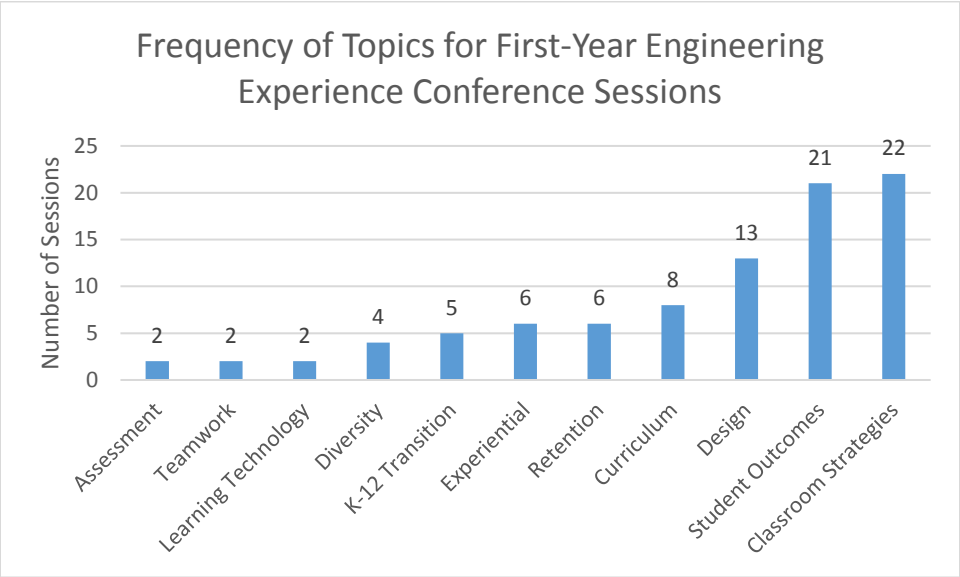

Figure 2: Number of FYEE Sessions Related to First-Year Engineering Education Themes

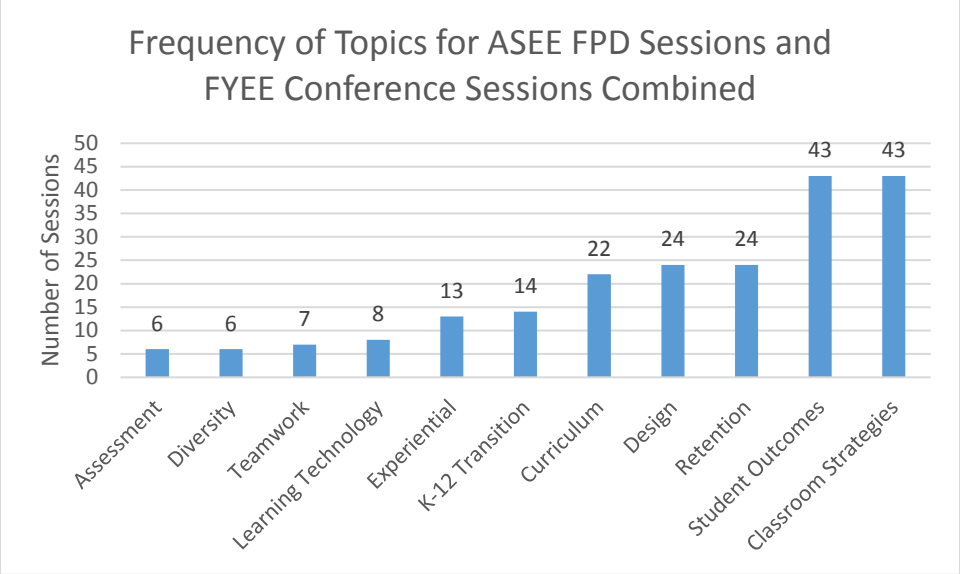

Figure 3: ASEE and FYEE Sessions Related to First-Year Engineering Education Themes

Figure 3 represents ASEE and FYEE sessions combined and as expected reveals a similar distribution to those presented in Figure 1 and 2. Student outcomes and classroom strategies are the most common themes for both conferences. Curriculum development, design, and retention form a second tier of the most common session topics. A third tier could include K-12 transition,

experiential learning, and learning technology, while a fourth tier could include teamwork, diversity, and assessment.

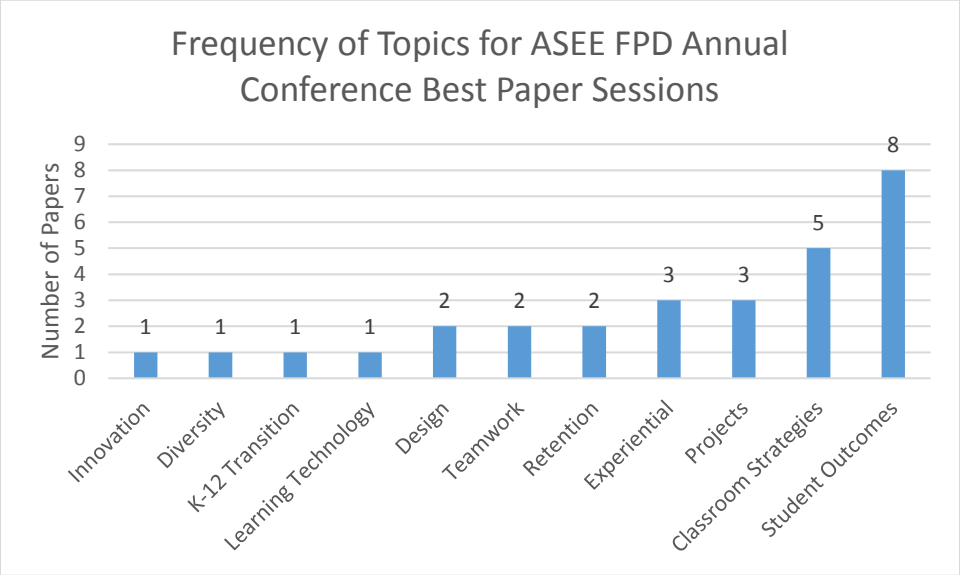

Figure 4: ASEE FPD Best Papers Related to First-Year Engineering Education Themes

The ASEE FPD best paper also has a higher frequency of student outcomes. Best papers also tended to focus on the themes of classroom strategies, project-based learning, and experiential learning.

Conclusions and Recommendation

The topics listed in Table 2 are compiled from the existing call for papers, session topics, and best papers in major conferences related to first-year engineering education research. They reflect the most frequent thematic topics in the compilation of papers presented in sessions at the ASEE FPD Annual Conference and FYEE Conferences. Qualitative analysis of publically available conference data was cross-referenced with the first-year engineering taxonomy. The topics in Table 2 should be used as sections for a first-year engineering education primer. The sections covering these topics in the primer should outline major research outcomes through a systematic literature review. The aim for this study is to build a primer to assist with the dissemination of evidence-based practice to engineering educators.

Table 2: Proposed Topics for First-Year Engineering Education Primer and Call for Papers

Topic	**Proposed First-Year Engineering Education Primer and Call for Papers Themes**
Research	Advances in engineering education research as it applies to the first-year experience;
Innovation	Innovative approaches to first-year engineering education;
Assessment	Pedagogical strategies for first-year learning objectives, ABET accreditation requirements, assessment;
Curriculum	Design, reform, evaluation, and classification of first-year engineering curriculum;
Experiential	Integrated experiential learning curricula & global/societal problems including service, research, and entrepreneurship for the first year;
Projects	Project-based, activity-based, and hands-on learning in the first year;
Design	Teaching and practicing the engineering design process in the first year;
Problem-Based	Creative, open-ended problem-solving courses and/or related teaching activities in first-year engineering programs;
Teamwork	Insights into teaming, group work, and team/individual assessment among first-year students;
Diversity	Inclusivity and diversity in the first-year engineering experience;
Retention	Retention and student success/motivation strategies for first-year students;
K-12 Transition	Programs that support the transition from K-12 to first-year engineering;
Recruitment	Programs, policies, or frameworks linking high school/two-year/transfer prep/junior college institutions and first-year programs;
Student Outcomes	Advising, student services, learning communities, orientation, tutoring, and other co-curricular first-year engineering student development programs;
Classroom Strategies	Professional development, technical communication, integration with math & sciences, major selection, peer-led team learning, and other models for first-year engineering;
Learning Technology	Instructional use of learning technologies, online tools, computational methods, and computer software in first-year engineering programs;
Space	Makerspaces, labs, equipment, materials to support learning in the first-year engineering experience

Some of the topics in Table 2 require further explanation or disambiguation. *Research* and *innovation* as themes are retained from the original call for papers because they have been a central component to both ASEE FPD and FYEE conferences. In this case *curriculum* refers to studies on the creation or modification of a first-year engineering course from the top-down. The topic of *student outcomes* include studies related to advising and student services connected to or provided outside the classroom that support student success. *Classroom strategies* refers to studies on common practices such as incorporating professional skills, communication, introduction to engineering profession and disciplines, and first-year math and science into the first-year engineering program. The *student outcomes* and *classroom strategies* sections in the primer could be broken down into subsections.

These topics can be used as a preliminary guide for creating a first-year engineering education primer. They are also relevant for the update of ASEE FPD and FYEE call for papers.

Table 2 can be used as a basis for the 2020 call for papers, and it might make sense for the call for papers to be the same for FYEE and ASEE. These summary topics can be used to plan future conferences and compile papers into sessions. A committee of past ASEE FPD and FYEE Program Chairs, a conference workshop, or some other panel should review and refine the initial findings in this study. Limitations of this study include possible errors while coding major themes, misidentification of session topics, and heterogeneous sessions. These limitations can be overcome by the systematic literature review and coding of individual papers which should be completed for the development of the first-year engineering education primer.

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Appendix A: ASEE FPD 2016-2019 Call for Papers

Topics	**ASEE FPD 2019 Call for Papers (Same Since 2016)**
Research	Advances in engineering education research as it applies to the first-year experience;
Retention	Retention and learner-support strategies for first-year students;
Innovation	Innovative approaches to first-year engineering education;
Experiential	Integrated contextual and practice-oriented curricula for the first year;
Projects	Project-based and hands-on courses and/or related teaching activities in the first year;
Retention	Retention strategies and programs applied in first-year engineering programs;
Diversity	Aspects of programs, course materials, and engineering education that address diversity among first-year students;
K-12 Transition	Pre-college programs and experiences, as well as links between first-year programs and K-12 education programs;
Recruitment	Programs, policies, or frameworks linking two-year/transfer prep/junior college institutions and first-year programs;
Design	Integrating engineering design into the first-year;
Teamwork	Insights into teaming, group work and team/member assessment among first-year students;
Problem-Based	Creative problem-solving courses and/or related teaching activities in first-year engineering programs;
Learning Technology	Instructional use of computers and computer software in first-year engineering programs;
K-12 Transition	Programs to assist engineering students in making the secondary-to-college transition, such as advising, and -to-college transition, such as advising, student services, orientation, and other co-curricular engineering student development programs

Appendix B: FYEE FPD 2015-2019 Call for Papers

Topics	**FYEE 2019 Current Call for Papers (Minimal Changes Since 2015)**
Assessment	Instruction/Pedagogy (e.g., curriculum design, ABET accreditation requirements and assessments, peer mentoring/teaching programs
Student Outcomes	Student Success/Development (e.g., learning communities, development models and what best procedures to promote the professional development of first-year students)
Student Outcomes	Academic & Career Advising (e.g. exploring engineering, understanding today's student, students on non-traditional pathways and advising students on probation)
Diversity	Diversity and Inclusion
Student Outcomes	First Year Student Orientation
Recruitment	Enrollment Management
Experiential	Service Learning in the first year and beyond
Learning Technology	Current technologies and their impact/use for first year students (including Hardware/Software/Product demo and use)
Space	Maker Spaces
Research	Engineering Education Research as it applies to the first-year experience
K-12 Transition	The Link Between K-12 and First Year Engineering
Mix	Other topics that address issues in education

Appendix C: FYEE FPD 2012-2014 Call for Papers

Topics	**FYEE Previous Version of Call for Papers 2012-2014 (Last Major Changes)**
Classroom Strategies	Various approaches and strategies to teaching engineering/science courses appropriate for the first year, both present and future
Research	Advances in Engineering Education Research as it applies to the first year experience,
K-12 Transition	Impact of K-12 education on our students
Student Outcomes	Understand today's students and how they are different from those a decade or two ago
K-12 Transition	How to improve the transition for students either from high school or transfer students
Student Outcomes	How does this present population of students impact the Introduction to Engineering Courses offered around the country
Student Outcomes	The role of Advising in the first year and how it impacts the students
Classroom Strategies	Effective uses of peer mentoring and/or student organizations
Learning Technology	Current technologies and their impact/use for first year students
Classroom Strategies	Student development models and what best procedures can be used to promote the professional development of the first year student
Diversity	Diversity in engineering, including the discussion of program that impact the pipeline into the K-12 area
Learning Technology	Use of Internet communication tools (e-mail, social networks, blogs, wikis, etc.) to improve the academic performance and retention of first-year students
Student Outcomes	Living and Learning communities both in a residential mode and peer mentoring in small group settings
Classroom Strategies	Integration of both business principles and the liberal arts to the curriculum
Experiential	Service Learning in the Freshman year and beyond
Mix	Other topics that address issues in education