



Creation of "The Engineering Student Experience Podcast" to enhance engineering student readiness for school and the workforce

Dr. Paul Morrow Nissenson, California State Polytechnic University, Pomona

Paul Nissenson (Ph.D. Mechanical and Aerospace Engineering, University of California, Irvine, 2009) is an Associate Professor in the Department of Mechanical Engineering at California State Polytechnic University, Pomona. He teaches courses in the thermal-fluid sciences, computer programming, and numerical methods. Paul's current research interests involve studying the impact of technology in engineering education. He has served on the ASEE Pacific Southwest Section Board of Directors since 2014, including serving as the PSW Section Chair for 2018-2019.

Dr. Jessica Ohanian Perez, California State Polytechnic University, Pomona

Jessica Ohanian Perez is an assistant professor in Electromechanical Engineering Technology at California State Polytechnic University, Pomona with a focus on STEM pedagogy. Jessica earned her doctorate in education, teaching, learning and culture from Claremont Graduate University. Her research focuses on broadening participation of marginalized group in engineering and investigating alternate paths to the field.

Mr. Cesar Moreno

Creation of “The Engineering Student Experience” podcast to enhance engineering student readiness for school and the workforce

Abstract

This “Complete Evidence-based Practice” paper describes an institutional strategy to support student success using technology. Over the past decade, audio podcasts have become a popular format for entertainment, news, and education. Although there are many podcasts that focus on science and engineering topics, none of them focus exclusively on helping students make more informed decisions about whether to pursue engineering, which engineering discipline best matches their interests, and how to prepare for a career as an engineering professional. This work details the creation and distribution of an audio podcast titled, “The Engineering Student Experience,” whose purpose is to help current and future engineering students thrive in college and beyond through long-form conversations with practicing engineers, engineering faculty, and engineering students.

In the United States, the demand for engineers is projected to grow at a rate three times greater than other fields, but degree production will not keep pace [1]. One possible factor is lack of knowledge about the field of engineering. Although the Next Generation Science Standards incorporate some fundamental engineering concepts in K-12 education [2], many teachers were not exposed to the field of engineering during college, limiting their students’ exposure and access to this field [3]; it is notable that 7 out of 10 practicing engineers also have a family member who is an engineer, demonstrating the importance of role models in gaining access to the field of engineering [4]. The podcast seeks to expose more students to this field, which could increase the rate of K-12 students considering engineering as a career.

Five episodes were created as a pilot project in 2018 and released on YouTube to gather initial feedback from the public. The episodes focused on specific engineering disciplines and first-hand experiences of current engineering students, junior career engineers, and engineering instructors. Feedback also was obtained from 48 engineering students in a first-year engineering experience course during Spring 2019. The students were asked to listen to two episodes and complete surveys that probed their opinions about the podcast’s format and the perceived usefulness of the podcast as a current student and future engineer. The pilot study data helped the authors understand the impact and best practices surrounding the use of podcasts to engage student learners. The feedback from engineering students was overwhelmingly positive; the majority of students obtained numerous useful ideas from the episodes, would recommend the podcast to friends, are interested in listening to future episodes of the podcast, and felt more likely to succeed as an engineering student and engineering professional. Based on the positive feedback from the engineering students, the authors decided to continue creating new episodes for the foreseeable future and to expand its availability through popular podcast platforms. Additionally, informal feedback was obtained from high school students to help ensure future episodes would better align with their interests.

This paper details the creation and distribution of a podcast for relatively low cost and includes recommendations for recording hardware, editing software, and distribution platforms that would

allow the podcast to reach a worldwide audience. The authors hope that this paper can be a blueprint for educators who desire to create a podcast of their own.

1. Introduction

Engineering programs in the United States typically have high attrition rates. The national average six-year graduation rate is consistently between 50-60%, and is considerably lower for African-American and Hispanic/Latino students compared to White and Asian students [5]. A meta-study by Geisinger and Raman (2013) reports that the high attrition rates are partly due to inadequate high school preparation, insufficient interest-in or commitment-to the field of engineering, inadequate advising, and a change in career goals [6]. Many engineering students enter their majors with minimal knowledge of the discipline [7] and many high school students report being interested in STEM-related fields, but are unprepared for this endeavor [8].

Seven out of ten practicing engineers also have a family member who is an engineer [4], which tends to marginalize students not traditionally served by the field of engineering due to a lack of role models. Although the six-year graduation rate for women is comparable to men [5] and the total number of engineering bachelor's degrees awarded to women has increased by 71% during 2006-2016, the percentage of engineering bachelor's degrees awarded to women held steady at approximately 20% over that decade [9]. This percentage may be a reflection of a lack of role models as women represented only 14% of the engineering workforce in 2017 [9] and only 17% of engineering tenure-track faculty positions in 2018 [10].

Another barrier for entering engineering programs is the prescriptive nature of engineering curricula [11]. The pipeline for becoming a successful engineering student is long, extending back to high school where students learn fundamental math and physics concepts. Students who first gain exposure to engineering in college may find it difficult to switch to an engineering program if they have not learned the pre-requisite material. Technology opens access to students at all grade levels, giving them the independence and autonomy to learn about the field of engineering in various modalities when the barrier to entering the pipeline is still relatively low [12]. Moreover, the ubiquity of smart phones provides open access regardless of location, socioeconomic status, gender, or culture [13], helping to level the playing field and giving students the power to decide what is learned and how it is learned.

While many universities have K-12 outreach programs for boosting interest in engineering, these programs tend to focus on the technical aspects of engineering (e.g., building a robot) rather than topics that would help students make more-informed decisions about whether to pursue engineering and how to succeed as an engineering student. Such topics include:

- What are the differences between engineering disciplines?
- What types of courses does an engineering student take?
- What are the differences between high school courses and college courses?
- What career paths are available to engineers?
- What is day-to-day life like for practicing engineers?

Additionally, once in college students often are given little guidance on how to prepare for an engineering career. Topics such as writing resumes, obtaining internships, preparing for job interviews, and understanding the gap between what is taught in the classroom and the

experience of a practicing engineer [14] are critically important for engineering students, yet often are discussed only in private conversations with faculty members or academic advisors.

Podcasts, which are programs available in a digital format that can be downloaded or streamed through the internet [15], are a potential tool for helping future and current engineering students make more-informed decisions about their future. During the past decade, audio podcasts have become a popular media format as they allow people to listen to shows on-demand anywhere. At the time of writing, over 800,000 podcast shows consisting of 30 million episodes have been created worldwide, covering a wide range of topics such as news, politics, society & culture, comedy, business, health, history, and music [16]. Podcast listenership has grown rapidly over the past decade – in 2019, 32% of Americans age 12 and older listened to a podcast in the last month, compared to only 11% in 2009. Most of the growth is due to the increased prevalence of smartphones [17]. As of 2019, most people listen to podcasts on their smartphone (70%) [16], and primary locations for listening to podcasts are at home (49%), while driving (22%), and at work (11%) [18]. Most podcasts can be accessed through various platforms such as podcast apps (e.g., Apple Podcasts, Stitcher, Spotify), YouTube, and podcast websites. Although most podcasts are free to the public, popular podcasts may include sponsored commercials or have additional content behind a paywall. One key feature of podcasts is that the user can subscribe through an RSS feed, allowing the user to be notified automatically when new episodes of the podcast become available. The user can then choose to stream an episode or download the episode to their device for future listening.

There are many engineering-related podcasts that focus on describing how everyday items work, careers in engineering, specific engineering disciplines, and entertaining engineering-related incidents [19], [20]. However, as of 2018 there were no podcasts dedicated to helping all current and future engineering students prepare for college life and becoming a professional engineer. To help meet this need the authors created an audio podcast series titled, "The Engineering Student Experience Podcast," which focuses on issues that concern current and future engineering students. The podcast's purpose is to enhance awareness of engineering as a major and as a career option, allowing students to take the necessary steps to increase the likelihood of success in college and beyond.

In order to assess the potential usefulness of the podcast, five episodes were deployed to a first-year engineering experience course at California State Polytechnic University, Pomona (Cal Poly Pomona) in Spring 2019. After listening to two episodes, 48 students completed surveys to obtain feedback about the following items:

- Listening habits
- Format of the podcast
- Perceived usefulness of the podcast as a current engineering student
- Perceived usefulness of the podcast for their future career as an engineer

The feedback was used to determine whether the podcast was valuable to students and should be continued, how to improve the podcast format, and to obtain ideas for future episodes.

2. Creation and distribution of podcast episodes

The authors had no experience producing podcasts prior to the pilot project, so the lead author (and host) completed a five-hour Lynda.com course titled, “Producing Professional Podcasts” [21]. The course was immensely helpful as it provided a framework for how to create and distribute podcasts, and contained numerous suggestions for hardware and interviewing techniques. The host consulted with staff at Cal Poly Pomona’s on-campus video production unit (MediaVision) as well.

In 2018, the authors received a small internal grant from Cal Poly Pomona to pay for recording hardware and teaching release time to create five episodes for a pilot project. The following equipment was purchased which allows the host to interview up to three guests anywhere electrical power is available:

- 1 Mackie ProFXv2 8-channel mixer (\$200)
- 1 Tascam DR-40 audio recorder (\$200)
- 1 SanDisk Ultra 128GB SD card (\$50)
- 4 Movo LV4-O2 XLR omnidirectional lavalier microphones (\$40 each)
- 4 Mpow Thor monitor headphones (\$30 each)
- 1 ART HeadAMP4 audio splitter for monitor headphones (\$80)
- Various cables (\$20)

Although non-lavalier cardioid condenser microphones likely would produce cleaner audio than the omnidirectional lavalier microphones used in this project, cardioid condenser microphones require the speaker’s mouth to remain very close to the microphone at all times to produce good audio, which can be awkward for a guest unaccustomed to being interviewed. The lavalier microphones can be attached to a shirt or coat, keeping the distance between the mouth and microphone constant and allowing guests to move their heads and bodies in a natural manner. Lavalier microphones also are easier to transport and are less expensive than higher-quality condenser microphones. The microphones were connected to the soundboard, which allows the sound levels from each microphone to be adjusted before being output to the audio recorder. The host and guests were given the option to monitor the output through headphones, but most preferred not to use headphones since hearing one’s own voice can be distracting.

Topics for the five pilot episodes were obtained through informal conversations with engineering students at Cal Poly Pomona. The episodes were recorded during early 2018 in a departmental meeting room since it was relatively quiet and in an area with low foot traffic. Although the room’s acoustics were not ideal – there was a slight hum from fluorescent lighting and minor echoing due to smooth walls – it was deemed sufficient for the purposes of the pilot project. Each episode focused on a different topic and consisted of the host interviewing two guests across a table. An undergraduate mechanical engineering student with experience in audio production was recruited to assist with running the soundboard during the interviews and later editing the episodes using Adobe Premiere Pro [22].

Each episode followed the same structure:

- Introductory music (15 seconds)
- Host's opening remarks (1-2 minutes)
- Music interlude (5 seconds)
- Interview (30 – 90 minutes)
- Music interlude (5 seconds)
- Host's concluding remarks (1-2 minutes)

In order to save costs, the music was obtained from an open source on YouTube.

All pilot episodes were released to the public by December 2018 on the Cal Poly Pomona Mechanical Engineering Department's YouTube Channel as an open educational resource [23].

The title, length, and description of each episode are listed below:

- *Episode 1, What's it like to be an early career engineer?* (1 hr, 12 min)
Two former mechanical engineering students from Cal Poly Pomona discuss their experiences working in industry during the past four years
- *Episode 2, What is Civil Engineering?* (38 min)
Two Cal Poly Pomona civil engineering faculty members discuss fundamental information about their discipline and the career paths available to civil engineers
- *Episode 3, What's it like to be an engineering instructor?* (1 hr, 21 min)
Two engineering faculty members discuss their path to becoming an instructor, as well as the challenges and rewards of being a faculty member
- *Episode 4, What is Mechanical Engineering?* (27 min)
Two Cal Poly Pomona mechanical engineering faculty members discuss fundamental information about their discipline and the career paths available to mechanical engineers
- *Episode 5, What's it like to be a senior engineering student?* (1 hr, 0 min)
Two senior-level undergraduate mechanical engineering students reflect upon their experiences as engineering students and provide tips for future engineering students

Although all of the interviewees are affiliated with Cal Poly Pomona, the interviews were conducted in a manner that the advice would be applicable to students at any institution. For example, when interviewing the mechanical engineering faculty members in Episode 4, the host asked the interviewees about the types of courses a mechanical engineering student would take at a typical institution, not the courses specifically offered at Cal Poly Pomona.

3. Deployment to first-year engineering experience students

Since current engineering students are a major target audience for the podcast, the authors sought feedback directly from students at Cal Poly Pomona. In Spring 2019, 48 undergraduate engineering students in a first-year engineering experience course were given a graded activity to listen to two episodes outside of class. After listening to each episode, the students completed a survey (administered confidentially through Blackboard) that explored their listening habits, the format of the podcast, and the perceived usefulness of the podcast as a current student and future engineer. The surveys helped determine whether students felt the podcast was useful and should be continued in the future, obtain recommendations for improving the podcast, and elicit ideas for future episodes.

The survey results are presented in Tables 1-3. Table 1 shows that students were mostly freshman, male, and represented a wide range of engineering majors.

Table 1: Demographics of the 48 students in the first-year engineering experience course

<i>Class level (n = 48)</i>		<i>Major (n = 48)</i>	
First year at CPP*, Freshman	69%	Mechanical Engineering	13%
First year at CPP, transfer student	2%	Civil Engineering	35%
Second or third year at CPP	23%	Electrical & Computer Engineering	8%
Four or more years at CPP	6%	Electromechanical Engineering Tech.	10%
		Industrial & Materials Engineering	8%
		Aerospace Engineering	8%
<i>Gender (n = 48)</i>		Chemical & Materials Engineering	8%
Male	71%	Other	8%
Female	27%		
Declined to state	2%		

Note: Percentages may not add to 100% due to rounding.

* CPP = Cal Poly Pomona

Students were given the option of listening to the episodes on YouTube or SoundCloud. While YouTube is the dominant video streaming platform in the United States, the authors felt that an audio-focused platform like SoundCloud might offer a superior listening experience. Both platforms allow creators to upload and distribute content to the world for free, although SoundCloud offers limited storage space before requiring a monthly subscription fee. Table 2 shows that over 60% of the students preferred to listen to the episodes through YouTube, while only about 20% preferred to listen through SoundCloud. It is unclear whether students preferred YouTube due to being more familiar with that platform or other reasons.

Over 80% of students listened to the podcasts at their home or dorm, which is much higher than the national average who listen to podcasts at home (49%) [18]. One possible reason for this discrepancy is that students were listening for a homework assignment and may have preferred to listen in an environment where they typically complete homework. Almost 80% of the students felt the typical episode length was "about the right amount of time" or "a little too long," and 95% of the students rated the host as being sufficiently engaging for the podcast. About 60% of the students "definitely" or "probably" would recommend the podcast to friends, with only 13% not recommending the podcast. Over 70% of the students would be interested in listening to more episodes in the future.

The students were allowed to select the two episodes for the assignment. Table 3 shows about half of the students listened to episodes on being an early career engineer (Episode 1), civil engineering (Episode 2), and mechanical engineering (Episode 4). One-third of the students listened to the episode on being a senior-level engineering student (Episode 5), while less than 10% listened to the episode on being an engineering instructor (Episode 3). The students seemed to select topics that are most relevant to their current situation and future plans since the two most common majors in the study were civil engineering and mechanical engineering, most students would become seniors in a few years, and most engineering students from Cal Poly Pomona work in industry after college.

Table 2: Student listening habits and feedback about the podcast format

Where did you listen to the podcast episodes most frequently? (n = 47)

At home or dorm	81%
At the gym	0%
At school (not dorm or school gym)	9%
In the car	4%
Other	6%

How did you listen to a typical episode? (n = 47)

Listened to the whole episode without breaks	62%
Listened to the whole episode with multiple breaks	38%

Which platform did you prefer for listening to the episodes? (n = 47)

YouTube	62%
Soundcloud	19%
No preference, both were fine	19%

What is your opinion about the typical episode length? (n = 47)

Way too long	17%
A little too long	36%
About the right amount of time	43%
A little too short	4%
Way too short	0%

What is your opinion about the host? (n = 46)

Very engaging	30%
A little engaging, sufficient for the podcast	65%
Not engaging enough for the podcast	4%

Would you recommend this podcast to a friend? (n = 47)

Definitely	23%
Probably	36%
Maybe	28%
No	13%

Would you be interested in listening to future episodes of the podcast? (n = 47)

Yes	72%
No	28%

Note: Percentages may not add to 100% due to rounding.

Table 3 shows that students generally found the episodes to be beneficial. For most episodes, over half of students reported encountering three or more ideas that are useful to them as a current student and as a future engineer. For all episodes, over 75% of students felt that they were "a little more" or "much more" likely to succeed as an engineering student and as a professional engineer after listening to the episode.

Table 3: Perceived benefit of individual podcast episodes

How many ideas were useful to you as a student?

	Episode 1 (n = 24)	Episode 2 (n = 24)	Episode 3 (n = 4)	Episode 4 (n = 26)	Episode 5 (n = 16)
6 or more ideas	4%	13%	25%	12%	50%
3-5 ideas	46%	42%	50%	31%	38%
1-2 ideas	50%	42%	25%	50%	13%
0 ideas	0%	4%	0%	8%	0%

How many ideas were useful to you as a future engineer?

	Episode 1 (n = 24)	Episode 2 (n = 24)	Episode 3 (n = 4)	Episode 4 (n = 26)	Episode 5 (n = 16)
6 or more ideas	17%	17%	25%	8%	19%
3-5 ideas	39%	58%	25%	39%	44%
1-2 ideas	44%	25%	50%	54%	31%
0 ideas	0%	0%	0%	0%	6%

After listening to the episode, I feel _____ likely to succeed as an engineering student.

	Episode 1 (n = 24)	Episode 2 (n = 24)	Episode 3 (n = 4)	Episode 4 (n = 26)	Episode 5 (n = 16)
much more	25%	38%	50%	15%	31%
a little more	54%	42%	25%	65%	56%
no more, no less	21%	17%	25%	15%	13%
a little less	0%	4%	0%	4%	0%
much less	0%	0%	0%	0%	0%

After listening to the episode, I feel _____ likely to succeed as an engineering professional.

	Episode 1 (n = 24)	Episode 2 (n = 24)	Episode 3 (n = 4)	Episode 4 (n = 26)	Episode 5 (n = 16)
much more	33%	29%	75%	12%	19%
a little more	63%	50%	0%	65%	69%
no more, no less	0%	13%	25%	19%	13%
a little less	4%	4%	0%	4%	0%
much less	0%	4%	0%	0%	0%

Note: Percentages may not add to 100% due to rounding.

The surveys also asked students to provide potential topics for future episodes. Many students requested episodes about other disciplines such as aerospace engineering and chemical engineering, obtaining internships, tips for studying effectively in college, the day-to-day responsibilities of engineers in various fields, and current engineering students describing their personal experiences in college.

In summary, the feedback from current engineering students was overwhelmingly positive. The majority of students obtained useful ideas, felt more likely to succeed as an engineering student and professional engineer, would recommend the podcast to friends, and are interested in listening to future episodes of the podcast. Additionally, at the time of writing the five pilot project episodes have a like:dislike ratio of over 90:1 on YouTube, indicating many others in the public found the videos useful as well.

4. Expanding podcast distribution and future work

After receiving the positive feedback from current engineering students, the authors decided to continue producing new episodes for the foreseeable future and to distribute the podcast to a wider audience. Many podcast listeners use podcast platforms (e.g., Apple Podcasts, Spotify, Stitcher, Google Play Music) to stream or download content. Listeners can access the platforms through apps on their smartphones or web browsers. In order for a podcast to become available on a platform, the creator must use a podcast hosting service to set up an RSS feed and submit the RSS feed to the platform for approval. Once the platform accepts the podcast, the podcast is available to anyone using that platform.

The authors selected PodBean for the hosting service after considering cost (less than \$10/month) and features offered by the service. At the time of writing, the podcast is available on all popular podcast platforms and through the podcast's website, greatly expanding the potential listening audience [24]. Episodes will continue to be uploaded to the Cal Poly Pomona Mechanical Engineering Department's YouTube Channel since the channel has over 50,000 subscribers and some listeners may not use podcast platforms [25], [26].

In its current format, the podcast is quite sustainable and episodes are being released at a rate of approximately one per month. After the initial cost of the recording hardware, the only on-going costs for the podcast are the monthly subscription fee for the hosting service (less than \$10/month) and paying a student assistant to run the soundboard during interviews (about \$30/episode that involves interviewing guests). The host has taken over editing duties to increase creative control over the podcast and to save money. Currently, the small on-going costs are covered by a grant related to increasing student success at Cal Poly Pomona. Although many popular podcasts have sponsorships and podcast ad revenue has increased by an order of magnitude in the last five years – from \$69M in 2015 to a projected \$659M in 2020 [18] – the authors have no immediate plans for monetizing the podcast through commercials.

The Spring 2019 study provided feedback from 48 current engineering students. Since the podcast's target audience also includes future engineering students, input from high school students was desired as well. In Summer 2019, the lead author visited the "Cal Poly Pomona STEAM Academy," which is a summer program at Cal Poly Pomona for local high school students who are strongly considering pursuing an engineering degree. During a focus group, about 40 high school students provided suggestions for future episodes. Many students had questions about fundamental concepts and definitions related to institutions of higher learning, such as:

- What are the differences between a college and a university?
- What does it mean to be a doctor or professor?
- How is a university structured?
- What is graduate school?

This focus group inspired the creation of a few short episodes that address basic, yet very important, concepts for high school students to understand when selecting an institution of higher learning. The authors plan to revisit the STEAM Academy in Summer 2020 to conduct a formal study on the perceived usefulness of the podcast by high school students, similar to the Spring 2019 study with first-year engineering experience students described in Section 3.

Based on the feedback from the engineering students and high school students, the short-term plans for the podcast are to produce more episodes on specific engineering disciplines (e.g., aerospace engineering), fundamental concepts about higher institutions (e.g., what is graduate school), day-to-day life for engineering professionals (e.g., aerospace companies, public utilities), and interviews with current engineering students describing their personal experiences (e.g., freshman students, first generation students). Additionally, starting in Fall 2020 the podcast will be recorded in a room with better acoustics to improve audio quality.

5. Tips for new podcasters

The authors began this project merely as podcast listeners with no experience in creating or distributing podcasts. Below are lessons learned for readers who are interested in starting their own podcast.

- Prior to purchasing equipment or conducting interviews, take an online course or watch tutorials on how to produce and distribute a podcast. Although this may take a significant time up-front, it can greatly increase the quality of your podcast.
- Listen to a variety of other podcasts to obtain ideas for interviewing techniques and how to structure each episode.
- Determine your podcast's purpose and target audience, and check if popular podcasts already fill that niche.
- Determine what resources are available at your institution, such as a recording studio and recording equipment. Although Cal Poly Pomona has a recording studio, the authors felt the studio's layout would not be comfortable for guests.
- Obtaining clean audio is very important, but can be challenging depending on your setup. As discussed in Section 2, during the pilot project both the host and guests used omnidirectional lavalier microphones in a room without ideal acoustics, resulting in a slight echoing effect. Using cardioid condenser microphones in a sound studio can greatly improve the audio quality, but it requires guests to be familiar with how to speak into condenser microphones properly.
- Audio podcasts are less difficult to produce than video podcasts (vodcasts). Typically, it is much easier to make edits in audio appear seamless, whereas edits to video will result in a sudden shift in everyone's positioning unless a two-camera setup is used. Additionally, many guests may feel more comfortable with an audio-only format compared to a video format.
- Provide guests with a list of topics ahead of time to give them the option of preparing for the interview. Some guests may request a list of specific questions that will be asked during the interview as well.
- Interviewing multiple guests in an episode offers significant advantages as it distributes the burden of carrying the conversation among more people and often produces a synergistic effect as guests interact with each other. However, for audio-only podcasts you should limit the number of guests to three at most since it can be difficult for the audience to keep track of four or more guests at a time.
- Just prior to recording, make the guests feel comfortable by engaging them in friendly banter, ask them if they have any questions, and reassure them that any errors can be removed in post-production.

6. Acknowledgments

The authors would like to thank the Cal Poly Pomona Special Projects for Improving the Classroom Environment (SPICE) grant for providing the seed money for this pilot project. Additionally, the authors thank Trevor Henderson (Director of Media Vision at Cal Poly Pomona) for advice and feedback about podcast, and Gerardo Maldonado (Cal Poly Pomona undergraduate mechanical engineering student) for helping run the soundboard during the Fall 2019 recordings.

References

- [1] R. Marra, K. Rodgers, D. Shen, and B. Bogue, "Leaving Engineering: A Multi-Year Single Institution Study," *Journal of Engineering Education*, 101(1), pp. 6-27, 2012.
- [2] Next Generation Science Standards website, Accessed January 2020. Available at <https://www.nextgenscience.org/>
- [3] C. Cunningham, M. Knight, W. Carlsen, and G. Kelly, "Integrating Engineering in Middle and High School Classrooms," *International Journal of Engineering Education*, 23(1), pp. 3-8, Oct. 2006.
- [4] I. Miaoulis, "K-12 Engineering – the Missing Core Discipline," in *Holistic Engineering Education: Beyond Technology*, D. Grasso and M. Burkins, Ed. New York: Springer, 2010, pp. 37-50.
- [5] B. Yoder, "Engineering by the Numbers: ASEE Retention and Time-to-Graduation Benchmarks for Undergraduate Engineering Schools, Departments and Programs," American Society for Engineering Education, Washington, DC, Tech. Memo, 2016. Available at <https://ira.asee.org/wp-content/uploads/2017/07/2017-Engineering-by-the-Numbers-3.pdf>
- [6] B. Geisinger and D. Raman, "Why They Leave: Understanding Student Attrition from Engineering Majors," *International Journal of Engineering Education*, 29(4), pp. 914-925, 2013.
- [7] R. Marra, B. Bogue, D. Shen and K. Rodgers, "Those that leave: Assessing why students leave engineering," in *Proceedings of the 37th ASEE/IEEE Frontiers in Education Conference*, Honolulu, HI, USA, October 10-13, 2007. Available at http://aweonline.org/asee07_why_they_leave@20_final@203-2-07.pdf
- [8] R. Chang, "Report: Many High School Graduates Want to Pursue STEM Careers but are Unprepared for STEM College Courses," *The Journal*, November 17, 2016. Available at <https://thejournal.com/articles/2016/11/17/many-high-school-graduates-want-to-pursue-stem-careers-but-are-unprepared-for-stem-college-courses.aspx?m=2>
- [9] K. Hamrick, "Women, minorities, and persons with disabilities in science and engineering: 2019," National Science Foundation, National Center for Science and Engineering Statistics (NCSES), Alexandria, VA, Special Report NSF 19-304, 2019. Data from Tables 5-4, 5-5, and 9-2. Available at <https://ncses.nsf.gov/pubs/nsf19304/data>
- [10] J. Roy, "Engineering by the numbers," American Society for Engineering Education, Updated July 15, 2019, Accessed January 2020. Available at <https://ira.asee.org/wp-content/uploads/2019/07/2018-Engineering-by-Numbers-Engineering-Statistics-UPDATED-15-July-2019.pdf>
- [11] M. Wang, J. Eccles, and S. Kenny, "Not Lack of Ability but More Choice Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics," *Psychological science*, 24(5), 770-775, 2013.
- [12] A. Johri, H. Teo, J. Lo, M. Dufour, and A. Schram, "Millennial engineers: Digital media and information ecology of engineering students," *Computers in Human Behavior*, 33, pp. 286–301, 2014.

- [13] T. A. Koszalka and G. Ntloedibe-Kuswani, "Literature on the safe and disruptive learning potential of mobile technologies," *Distance Education*, 31(2), pp. 139–157, 2010.
- [14] A. Warsame, "The Gap Between Engineering Education and Postgraduate Preparedness," Ph.D. dissertation, College of Education, Walden University, Minneapolis, MN, October 2017. Available at <https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=5289&context=dissertations>
- [15] Merriam-Webster, Accessed January 2020. Available at <https://www.merriam-webster.com/dictionary/podcast>
- [16] R. Winn, "2019 Podcast Stats & Facts," Podcast Insights website, Updated December 11, 2019, Accessed January 2020. Available at <https://www.podcastinsights.com/podcast-statistics/>
- [17] "Audio and Podcasting Fact Sheet," Pew Research Center, Published July 9, 2019, Accessed January 2020. Available at <https://www.journalism.org/fact-sheet/audio-and-podcasting/>
- [18] G. Whitner, "The meteoric rise of podcasting: Insights about the most compelling audio format," Music Oomph website, Updated December 2019, Accessed January 2020. Available at <https://musicoomph.com/podcast-statistics>
- [19] "Top Engineering Podcasts," Born to Engineer website, Accessed January 2020. Available at <https://www.borntoengineer.com/resources/top-engineering-podcasts-stem-podcast-list-top>
- [20] "Preparing Technicians for the Future of Work" podcast website, Accessed January 2020. Available at <http://preparingtechnicians.org/podcasts-webinars-page01.php>
- [21] "Producing Professional Podcasts" online course, Accessed January 2020. Available at <https://www.linkedin.com/learning/producing-professional-podcasts/welcome?u=56973593>
- [22] Adobe Premiere Pro website. Accessed January 2020. Available at <https://www.adobe.com/products/premiere.html>
- [23] Playlist of Episodes 1-5 of "The Engineering Student Experience Podcast" on YouTube. Available at https://www.youtube.com/playlist?list=PLZOZfX_TaWAHjr_YC1oEKae9CfYersmn7
- [24] "The Engineering Student Experience Podcast" website. Available at <https://theengineeringstudentexperience.podbean.com/>
- [25] Cal Poly Pomona Mechanical Engineering Department's video library, ME Online. Available at <https://www.cpp.edu/~meonline/the-engineering-student-experience-podcast.shtml>
- [26] P. Nissenson, N. Tsuchiya, M. Jawaharlal, and A. Shih, "Creation of an Online Video Tutorial Library at a State University," in *Proceedings of the 126th ASEE Annual Conference and Exposition*, Tampa, FL, USA, June 15-19, 2019. Available at <https://www.asee.org/public/conferences/140/papers/24599/view>