

## **Assessing the Influence of an Online Video Tutorial Library on Undergraduate Mechanical Engineering Students**

**Prof. Juliana Lynn Fuqua, California State Polytechnic University, Pomona**

Juliana Fuqua, Ph.D., is a Professor in the Department of Psychology at California State University Polytechnic, Pomona, who completed her doctoral degree at the University of California, Irvine. Dr. Fuqua's dissertation at the University of California, Irvine, was an evaluation of transdisciplinary scientific collaboration, which was part of a large National Institutes of Health Initiative. Dr. Fuqua is a quantitative and qualitative consultant, trained in survey methods, statistics, focus groups, interviews, and program evaluation. Consulting work has included local and national transdisciplinary endeavors. Current interests include evaluation of innovations in STEM products and education, transdisciplinary scientific collaboration, and understanding how the social and physical environment interacts with human development and behavior.

**Dr. Faye Linda Wachs, California State Polytechnic University, Pomona**

Faye Linda Wachs is a professor of Sociology in the Department of Sociology at California State Polytechnic University, Pomona. Dr. Wachs received her Phd in Sociology from the University of Southern California, along with a graduate certificate in gender studies. Dr. Wachs' published work focuses on gender equity, health, fitness, media, sport, sexuality and consumerism. Her book, *Body Panic: Gender, Health and the Selling of Fitness*, co-authored with Shari Dworkin was the recipient of the North American Society for Sport Sociology (NASSS) Distinguished Book Award in 2010. She is the California State Polytechnic University, Pomona 2012 Provost Award Winner for Distinguished Service as well as the 2009-10 Cal Poly Pomona College of Letters, Arts and Social Sciences Outstanding Advisor. Dr. Wachs is the former president of an international academic organization, the North American Society for Sport Sociology. Dr. Wachs' current research focuses on the impact of facial paralysis, innovative research methods, social media and identity and STEM Education. In her spare time, Dr. Wachs enjoys hiking, running, biking, sailing, knitting/crocheting/sewing and spending time with her family and dogs.

**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 and Associate Chair of 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 main 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 as the PSW Section Chair for 2018-2019.

**Ms. Deanna Miranda Barrios**

**Ms. Cecilia Nguyen, California State Polytechnic University, Pomona**

## **Assessing the influence of an online video tutorial library on undergraduate mechanical engineering students**

### **Abstract**

Since 2013, the Mechanical Engineering Department at California State Polytechnic University, Pomona (Cal Poly Pomona) has created over 600 videos for its curriculum across 12 courses. These videos are available to the public as an open educational resource at the “ME Online” website ([www.cpp.edu/meonline](http://www.cpp.edu/meonline)), which has accumulated over 8,600,000 views as of March 2021. In 2018, a brief survey was administered to 340 mechanical engineering students at Cal Poly Pomona as part of a pilot study to investigate the impact of ME Online [1]. The survey results were promising – the vast majority of students felt the video library made a positive impact on their education and helped their grades in at least one course. However, the survey did not explore the socio-emotional impact of the video library on students nor obtain specific recommendations of how the video library could be improved to enhance student success.

The current study was designed to gain a deeper understanding of how ME Online influences student success and obtain ideas of how to improve ME Online. During Spring 2020, the authors studied the impact of ME Online on senior-level mechanical engineering students at Cal Poly Pomona using surveys ( $n = 110$ ) and focus groups. Survey results indicated almost every student (96%) was aware of the resource and used the resource at least once, with students watching an average of 1.8 hours of video per week. At least 80% of the students rated the videos as “moderately” to “very” helpful, useful, satisfying, confidence-inducing, and enjoyable. The videos were rated as especially helpful for courses with higher failure rates. Despite the videos being highly regarded, students viewed the videos as a good supplement rather than a replacement for professors and peers when they needed help. Nearly all students (96%) provided favorable ratings about the trustworthiness of the video library and most students trusted the ME Online videos more than other videos available online. They were particularly happy when finding videos by their favorite instructors who were clear, engaging, and knowledgeable. Most students plan on using ME Online as alumni for both professional and personal reasons – 88% of the students reported they expect to use ME Online to study for licensing exams, graduate school work, professional work, and/or just to learn new things.

The study also explores the potential for video libraries like ME Online to help address achievement gaps among historically disadvantaged groups. Latinx students and first-generation students used ME Online more frequently than other students, and generally rated the resource more highly than other groups. In particular, they noted the importance of being able to pause and control the pace of delivery, which is especially useful for non-native English-speaking students.

The authors provide suggestions for improving video libraries such as focusing on courses that have higher failure rates, frequently reminding students about the resource, being aware of differences between the topics emphasized in a course and topics covered in the videos, and adding videos for non-major core courses such as physics.

## **1. Introduction**

Over the past two decades, the creation of open courseware materials has led to dramatic growth and evolution of course materials and the technology that supports them. Today, free textbooks are available for a wide variety of subject areas [2], [3], and many universities have developed large databases of video content and other educational resources that are available to the public [4], [5], [6]. Additionally, many self-paced online courses have been created, sometimes in partnership with massive open online course (MOOC) platforms such as Coursera and edX [7], [8] – over 13,000 MOOCs have been created as of 2019 [9].

Advances in recording technology and hosting services have greatly lowered the cost of creating and distributing educational content to a worldwide audience. For a few hundred dollars, instructors can obtain recording and editing software (e.g., Camtasia Studio, iMovie, Adobe Premiere Pro) and a microphone to create high-quality videos which can be shared for free through platforms like YouTube. While many individual instructors routinely create videos for their students, the videos may not meet accessibility standards due to poor video quality, poor audio quality, incomplete audio descriptions, and inaccurate captions [10], [11], [12]. This is especially true of the rapid transition to online instruction necessitated by the COVID-19 pandemic. Hiring professional videographers and editors can help improve the quality and accessibility of videos, but the high cost associated with such services, along with paying for faculty release time to help make the videos, is a significant barrier for primarily undergraduate institutions (PUIs) such as community colleges and state universities. Prestigious universities with large endowments, such as many Research 1 (R1) universities, can absorb this cost more easily and is a key reason why they are associated with some of the largest and best-known video repositories. Additionally, since high-quality videos are required for MOOCs, it is not surprising that MOOC platforms' directories of university partners are dominated by well-known R1 institutions and have relatively few primarily undergraduate institutions (PUIs) [13], [14]. Despite the economic barriers, it is possible for primarily undergraduate institutions to create their own video repositories that are better tailored to the needs of their specific curriculum and student populations.

### ME Online: An online video tutorial library

A large repository of video tutorials, referred to as “ME Online,” has been developed since 2013 by the Mechanical Engineering Department at California State Polytechnic University, Pomona

(Cal Poly Pomona), which is a primarily undergraduate institution. ME Online contains over 600 videos for 12 engineering courses which were created by more than half of the department's faculty members and various other groups at the university. More information about the content and type of videos is available in Nissenson et al. (2019) [1]. The videos are available to students and the public, and are hosted on a departmental YouTube account; the ME Online website is used to organize the videos in a user-friendly manner [1], [15], [16]. As of March 2021, the video library has accumulated over 8,600,000 views, 740,000 hours of total viewing time, and 75,000 subscribers from around the world.

Some mechanical engineering faculty at Cal Poly Pomona require students to use ME Online videos for innovative teaching strategies (e.g., flipped classroom), and all students in the department have access to the videos as a supplemental resource. To help understand the usage of ME Online on current undergraduate mechanical engineering students at Cal Poly Pomona, a pilot study was conducted in 2018 using a survey deployed to 340 students. The results were encouraging – 74% of students viewed ME Online videos multiple times per term, 88% of students indicated that the content made at least a small positive impact on their education, and 79% of students believed the videos have positively impacted their grades in at least one course [1].

*The pilot study did not explore the socio-emotional impact of the video library on students, nor obtain specific recommendations of how the video library could be improved to enhance student success.* The current study uses a mixed methods approach with surveys and focus groups of senior-level mechanical engineering students to gain a deeper understanding of how ME Online influences student success, and to solicit ideas for improving ME Online. It is the authors' hope that this paper will allow other engineering and non-engineering departments to appreciate the potential benefits of developing their own video libraries, as well as help improve existing video libraries.

## **2. Literature Review**

### Blended Learning

The videos in the ME Online library are not designed to replace classroom instruction. Rather, they are intended to be used as part of a blended learning approach or as a supplemental resource. “Blended learning” is a pedagogical approach in which traditional classroom instruction is paired with additional online educational material to enhance learning. In a course that uses blended learning students are expected to develop learner autonomy, using online tools as supplements. These tools are often fun and can include media deemed favorable by students such as television shows, social networking sites, and short videos, and the appealing nature of such media assists student learning [17].

With the development of low-cost, user-friendly technologies over the past two decades, universities have become more interested in blended learning. Supplemental videos are an intervention used successfully by engineering programs, and previous research demonstrates improvement in student knowledge and performance, as well as usage spikes prior to deadlines and exams. Supplemental videos “provide an active demonstration of the material, they are convenient, and they bridge the gap between lecture and homework” [18]. Ideally, the videos are short, [19], [20], [21] focused, and facilitate student use. Supplemental videos also have been shown to improve grades and students have reported believing the videos enhanced understanding [22].

Blended learning is effective because it includes access to a variety of resources and modalities. A library of supplemental videos provides an alternative to relying solely on synchronous lectures, which has been especially important during the current COVID-19 pandemic. However, more research is needed to better understand which groups of students benefit the most from the videos. Previous research demonstrated videos are most beneficial for students requiring remediation, students in bottleneck courses, and especially for students in challenging courses [23]. In addition, Wieling & Hofman [24] demonstrated that viewing online lectures, along with attending lectures in person, has a statistically significant positive effect on exam grades for students in general, and greater benefits for students with work obligations, family commitments, and commuter students. Videos may be especially beneficial for students who are non-native speakers of English and assist students in mastering the language of their academic discipline [25].

#### First-generation and Latinx college students

Underrepresented students and first generation college students in STEM majors are likely to need access to supplemental resources such as ME Online. Bettencourt et al. (2020) found that first generation college students were less likely to complete a STEM degree than those who had at least one parent with a four-year college degree (9% to 15%) and were enrolled in less advanced math classes than their counterparts [26]. Latinx students and other racial minoritized groups (e.g., students who are Black, Native American) remain underrepresented in engineering [27] and have lower persistence and graduation rates [28].

#### Previous studies on ME Online

In 2018, a brief survey was administered to 340 mechanical engineering students at Cal Poly Pomona as part of a pilot study to investigate the impact of ME Online [1]. The vast majority of students felt the video library made a positive impact on their education and helped their grades in at least one course. However, the survey did not explore the socio-emotional impact of the video library on students nor obtain specific recommendations of how the video library could be improved to enhance student success.

The authors also conducted several studies that utilized ME Online videos as part of pedagogical experiments [29], [30], [31], [32], [33], [34], including studies that investigated the impact of a flipped classroom format on student performance and attitudes. For example, videos on fluid mechanics concepts were used to successfully flip a bottleneck fluid mechanics course, in which students watched videos before coming to class, and class time was used for engaging activities – the rate of students receiving a D or F dropped from a historical average of 34% down to 11% in the flipped sections [31].

#### Research purpose statement

The purpose of the present study is to assess ME Online more broadly as a departmental resource and to determine how different groups of students use and perceive the videos, as well as determine how they have been impacted by ME Online.

### **3. Assessment plan**

As noted in the research purpose statement above, the goal of this study is to examine the impact of the ME Online video library on undergraduate students holistically. The authors did not examine the impact of individual videos or individual subject areas on student learning, nor examine the impact of the website design on the student experience. While knowledge of such information could be quite useful, it was beyond the scope of the study.

To understand the impact of ME Online, a mixed methods study was designed. This sort of mixed methods approach provides useful and applicable research [35]. Having a range of supplemental resources is imperative at a University that serves students facing disparate challenges to educational success. Our university has a high proportion of immigrants, children of immigrants, first-generation college students, working students, low-income students, and student parents. For example, the university has a high proportion of first-generation students (58%), Latinx students (49%), Asian American students (21%), and students who come from low income households (70% receive financial aid, 44% receive Pell grants).

#### Participants

In April 2020, 110 mechanical engineering students at Cal Poly Pomona were recruited from a required senior-level undergraduate course (ME 4622: Undergraduate Seminar) to participate in this study. The participants' ethnicity in this study is presented in the results section.

The authors chose to recruit senior-level students because they have had the opportunity to use the ME Online video library for several years and for multiple courses, compared to students still taking lower division courses. Students usually enroll in ME 4622 the semester before graduation, and the survey was completed a few weeks before the end of the term. The participant group size represented a majority of the enrolled students in the course. The students

received a small amount of extra credit in their course for their participation in the study, and it was optional for students to include their name on the survey.

### Survey Questions

The 15-minute online survey consisted of 70 questions focused on demographics, usage rates of ME Online and other video libraries, perceived usefulness of the video library, and suggestions for improving ME Online in the future. Specifically, students were asked about their awareness of ME Online, their usage frequency, the reasons for usage, the importance of the resources available to them, the courses they use ME Online for, and their overall perceptions of ME Online (satisfaction, helpfulness, usefulness, enjoyability). Students also were asked about changes in their usage after the transition to online instruction in March 2020 due to the COVID-19 pandemic. After implementing the survey, researchers obtained permission to access overall GPA (i.e., student's GPA across all colleges and universities that they attended), university GPA (i.e., student's GPA for courses taken at the university), and major GPA (i.e., student's GPA in major core courses).

### Focus Groups

Students who completed the online survey also were invited to participate in a focus group in April 2020. Almost half of all survey participants ( $n = 49$ ) signed up to participate 1-2 weeks before the focus groups began. However, only 42% ( $n = 21$ ) of the students who originally signed up actually participated. The challenges created by the recent transition to online coursework due to the COVID-19 pandemic might explain why the participation rate was rather low.

The focus groups were designed and facilitated by a team of 11 Psychology Department and Sociology Department undergraduate research assistants who received training in qualitative and quantitative data collection. The mechanical engineering students were encouraged to speak freely about their thoughts and opinions, and the authors felt students would be more honest with peers compared to faculty researchers. Due to the COVID-19 pandemic, these focus groups were conducted and audio recorded via Zoom conferences rather than in person. After creating and reading the transcriptions from the focus groups, the team conducted content analysis of student responses to identify themes. By following a mixed method model, data can be corroborated and enhanced [35]. In focus groups, questions that arose in the quantitative collection phase were explored in-depth.

## **4.1 ME Online usage rates and student perceptions**

Survey and focus group data clearly indicate that students are using ME Online. Almost every student in the sample (96%) was aware of the resource and recalled watching an ME Online video at least once. Students used ME Online an average of 1.8 hours per week, with two-thirds

of the students reporting using ME Online 11-60 minutes per session on average. Many students appreciated watching videos while they were studying at home and needed immediate help. Often the catalyst for using the videos was anxiety related to quizzes, exams, or difficult homework assignments. Students greatly appreciated having access to “trustworthy” videos and being able to pause and rewind when they needed help understanding material. Students who spend a lot of time in paid employment, caregiving, or extracurricular activities were especially happy to have access to the videos if they had been late or absent from class. Several themes emerged from analyzing survey and focus group data about ME Online, which are discussed below.

*Videos are a great supplement and not a replacement for lecture:*

Students felt that the videos were not a replacement for interaction with professors and peers when they needed help, but the videos were a valuable and appreciated supplement. While they liked the videos, they felt human interaction was imperative. In fact, students ranked peer study groups and faculty office hours as the two most impactful factors in their success in engineering, followed by ME Online. Students indicated that videos should not replace lecture, but rather augment lectures and assist them when unavoidable absences occur, they need to hear the information repeated, or they did not understand something in context. Students lamented the lack of in-person interaction due to the pandemic, even as they indicated that they valued and appreciated resources like ME Online. One mournful undergraduate stated:

“I think that it's harder sometimes for me to understand things when I'm not like in a classroom setting. In class, I have friends who I can ask and be like, ‘Hey, what did the instructor just [say]? Can you explain this to me?’ ... It's just a lot harder when everyone is at home ... [So, the videos help when you are at home and can't talk to a friend as easily.]”

*Videos are highly regarded:*

ME Online is perceived quite positively by students. On many survey questions, students gave ME Online videos top ratings. At least 80% of students held very favorable views – i.e., students rated the videos as “moderately” to “very” positive on metrics such as helpful, useful, satisfying, confidence-inducing, and enjoyable on 7-point Likert-scales. Students provided additional positive remarks in focus groups about how the videos were helpful to them. As discussed in greater detail below, students liked ME Online because the videos allowed them to hear particularly confusing information again or in a new way outside of class, it raised their confidence in their ability to succeed in particularly difficult courses, and they liked knowing the videos were from faculty on their campus who would be teaching in ways consistent with their programmatic requirements.



*Videos help students in high-failure rate courses:*

Students commented on the survey and in focus groups that they used ME Online in difficult courses to repeat information they did not understand in class, especially while studying during nights before exams or homework assignment deadlines. Consistent with existing studies [23], students rated ME Online as most useful for difficult courses with higher failure rates such as Heat Transfer, Fluid Mechanics, and Stress Analysis. Videos for elective courses like Intermediate Dynamics, as well as courses perceived as easier such as lab-related courses, were considered less useful. This suggests departments that are interested in creating their own video libraries should consider focusing on mandatory courses with high failure rates to maximize impact. Furthermore, departments which are concerned about the effectiveness of instructors in a difficult course could encourage faculty who teach that course to create videos as a supplemental resource.

*A variety of video types are appreciated and short duration is preferred:*

Students mentioned that they appreciated a variety of styles and lengths of videos. For example, students appreciated the type of videos that are full-length lectures “in case they were late, sick, or had to miss class for other reasons.” They also appreciated videos of short duration that were supplements to lectures given in class. While students appreciated both styles of videos, overall they favored shorter videos, which is consistent with other studies [19], [20], [21].

*More trustworthy than other videos:*

On surveys, nearly all students (96%) provided favorable ratings about the trustworthiness of ME Online, with 58% of the students giving the highest possible rating. Additionally, students generally trust the ME Online videos more than other videos available online. In focus groups, students explained that they often would search for help online and were pleased to find Cal Poly Pomona resources such as ME Online. Students trusted the videos from their own department and were particularly happy if they found videos by their favorite instructors. Some instructors were highlighted as being especially clear, engaging, and knowledgeable. This is consistent with literature that suggests personalization and connection to videos is an important component and provides a reason to create department specific libraries [22].

Some students preferred videos from a range of instructors, though a few noted a preference for videos from the instructor of record. This suggests that students could benefit from more than one video on the same topic, but taught in different styles.

*Needed earlier in college:*

While students generally appreciated having access to the videos, 19% were unhappy that they were not fully aware of the resource until late in their academic career. “I wish I had known about it earlier,” lamented one student. Some students said they stumbled upon the videos while searching for any online resources, while other students reported discovering the resource

through word-of-mouth (classmates or instructors). They expressed the need for frequent reminders by faculty that ME Online exists, especially when students are in their early years in the program. One student noted:

“When I first learned about the videos, I think it was, like, the end of my second year or early third year, and I remember looking at all of the videos there. And I was like, ‘Oh shoot! I could have used these!’ ... [The college should] make it clear that the videos are there in, like, an ME student's first year and, like, really promote the videos so students know even just starting from their first year that ME Online is, like, going to be there for them [in their college career].”

*Useful after graduation:*

ME Online is a sustainable resource that most students (88%) plan on using as alumni for both professional and personal reasons, such as studying for licensing exams, graduate school work, professional work, and/or just to learn new things. They appreciated how easy it is to refer to the videos online, as noted by this student:

“I would use ME Online [in these situations] ... (1) if I wanted to get a refresher on anything, (2) in grad school, (3) definitely, if I was encountering a problem like during work or something. Definitely, students plan to use ME Online [in the future].”

Another student appreciated having the videos tailored to the needs of students at their university, which would help them in the future:

“It is easy for us to go [find and watch] exactly those videos which are tailored for our specific school ... I would use ME Online in the future, like when we have to take the Fundamentals of Engineering [a standardized professional exam], and to get our license and stuff like that. I'll definitely go back, and those would be the videos I would watch first”.

Although not studied in this paper, it would be interesting to explore the potential for a resource like ME Online to keep alumni involved with departments.

## **4.2 ME Online and achievement gaps**

Cal Poly Pomona is a Hispanic Serving Institution (HSI) and an Asian American Native American Pacific Islander Serving Institution (AANAPISI) situated in an area that has a lower median income, lower levels of educational attainment, lower levels of home ownership, and people more likely to be non-native speakers of English, than many other universities. Our students often arrive with comparatively lower test scores in critical subject areas. One potential

benefit of ME Online is that students with challenges can use the platform to get additional assistance, helping to reduce achievement gaps for the most vulnerable and challenged students. Indeed, some struggling students described ME online as a “life saver,” with one student exclaiming during a focus group:

“So the videos [ME Online] pretty much *saved my life* in a lot of classes! When I’m in class, it’s very hard for me to concentrate while taking notes ... [Using the videos outside of class,] I can pause the video, take notes, and go back. Honestly, the videos helped me pass a lot of my classes.”

This study explored whether students who are from certain historically disadvantaged groups are using ME Online more than other students, and whether they are being positively impacted. Specifically, the authors chose to look at Latinx students and first-generation students (defined as arriving in the U.S. after the age of 16) knowing they can have particularly strong need for resources to facilitate success. National data reveals lower scores on standardized tests that measure math skills necessary for success in the engineering major, for first generation, and Latinx students [36].

#### Racial breakdown of participants

In the present study, only the three largest ethnic groups in the ME major were chosen for ethnic disparity analysis as there were too few students in other groups for statistical analysis. The race distribution of students who completed the survey was 29% Latino/Latina/Latinx, 28% White/Caucasian, 23% Asian American, 7% Middle Eastern/Armenian/Persian/Iranian/Afghan/Iraqi, 5% Multiethnic/Multiracial, 3% Pacific Islander, 2% Native American/American Indian/Alaskan, 2% other, and 1% did not disclose. Focus group participants had a diversity of racial backgrounds similar in numbers to the survey respondents – primarily Latinx, White, and Asian American students, with almost no other racial groups.

#### Latinx students have lower GPAs and use ME Online more

Historically, the achievement gap between Latinx students and other groups in engineering programs has required redress (or greater attention and improvement), even at HSIs [37]. This is true of the current sample as well. Moreover, although the student population of Cal Poly Pomona is approximately 40% Latinx, the mechanical engineering majors are only 29% Latinx, indicating that Latinx students are under-represented in this major relative to the larger campus.

In the analyses, t-tests were used and a p-value of 0.05 set to compare groups of students’ GPA and reported usage rates of ME Online. All t-tests in this study were two-tailed unless otherwise indicated. Three different GPAs were considered: “Overall GPA” includes all college courses completed, “CPP GPA” includes only courses taken at Cal Poly Pomona, and “major GPA”

includes only mechanical engineering courses. Results were consistent across GPAs. All three types of GPA were examined because many of our students transfer from community colleges.

Latinx students had lower GPAs and a higher usage rate of ME Online than other groups. Table 1 shows that compared to Asian students, Latinx students had a lower mean overall GPA ( $t = -2.068, p = 0.045$ ), CPP GPA ( $t = -2.435, p = 0.019$ ), and major GPA ( $t = -2.695, p = 0.01$ ). Compared to White/Caucasian students, Latinx students had a lower mean overall GPA ( $t_{\text{one-tailed}} = -1.765, p = 0.045$ ) and CPP GPA ( $t = -2.194, p = 0.042$ ). Latinx students had a higher mean usage of ME online ( $X = 2.50$ ) than White/Caucasian students ( $X = 1.26$ ) ( $t = 2.96, p = 0.006$ ). Given that differences in pre-college experiences (e.g., access to advanced coursework and quality experiences) explain much of the achievement gaps demonstrated by Black and Latinx students in STEM [27, 38, 39], providing supplemental resources creates ways to address existing inequities.

Table 1: Ethnic group differences in mean usage rate of ME Online and mean GPA

Ethnic Group	ME Online Usage (hours/week)	Overall GPA	CPP GPA	Major GPA	% of Sample	Statistically Significant Ethnic Group Differences
Latinx	2.50	3.08	2.96	2.89	29%	–
White/Caucas.	1.26	3.28	3.22	3.09	28%	Latinx vs. White: Overall GPA, CPP GPA, Usage
Asian Am.	1.85	3.34	3.27	3.23	23%	Latinx vs. Asian Am.: Overall GPA, CPP GPA, ME GPA

There were multiple ethnic differences in the survey responses regarding the attitudes toward ME Online. T-tests revealed that Latinx students felt more positive about ME Online compared to Asian American students, rating the videos as being more helpful, satisfying, and useful in preparing them for their major courses ( $p < 0.05$ ). Additionally, Latinx students rated the videos as more confidence-boosting, enjoyable, and useful compared to Asian American students. Overall, Latinx felt the videos helped them learn more of what was required for their courses.

In focus groups, students provided multiple positive reactions when asked about the videos. Latinx students provided particularly favorable responses. They described multiple factors they liked about ME Online, including the ability to pause content delivery (which cannot be done in a live class) and the ability to watch videos if they did not understand the material or if they had to miss class. Latinx students noted the importance of repetition and increased comprehension, with one student commenting, “The videos were clear and easy to follow. Hearing it a second time by another professor helped.” A second student mentioned, “The videos really help me fully understand topics that I cannot understand. Very thorough. Dr. Biddle’s lectures are by far the best.”

While a statistically significant difference in GPA exists for Latinx students compared to White/Caucasian and Asian American students, Latinx students also are using ME Online more frequently and are responding positively about the resource. Although it was not possible to quantify the direct impact of ME Online on student learning and GPA in this study, the survey and focus group data highlights the potential of resources like ME Online as one way to address equity gaps.

First-generation students have higher GPAs and use ME Online more

The authors examined whether immigration status might be associated with ME Online usage rates. Among the survey respondents, 21% were first-generation (arrived in the U.S. after the age of 16), 10% were 1.5 generation (arrived in the U.S. as a child), 36% were second generation (born in the U.S. with at least one immigrant parent), 15% were third generation (born in the U.S. with at least one immigrant grandparent) and 18% were other (4+ generation). The survey explicitly stated that citizenship was not relevant in defining generational status; only when a student’s family immigrated to the U.S. was of interest. An ANOVA test indicated there were statistically significant differences in self-reported ME Online usage rates and GPA by generational status, as shown in Table 2.

Table 2: Generational status, mean use of ME online, and mean GPAs

Generation	ME Online Usage (hours/week)*	Overall GPA**	CPP GPA**	ME GPA**	% of sample
1 <sup>st</sup>	2.59	3.45	3.36	3.34	21%
1.5	1.68	3.10	3.02	2.99	10%
2 <sup>nd</sup>	1.92	3.12	3.05	2.93	36%
3 <sup>rd</sup>	1.19	3.42	3.35	3.26	15%
4 <sup>th+</sup> / other	1.19	3.10	3.05	2.94	18%

\* A statistically significant difference exists between the groups at the  $p < 0.05$  level

\*\* A statistically significant difference exists between the groups at the  $p < 0.01$  level

The first- and third-generation students had higher GPAs than the students in the other generational groups. Additionally, the first-generation students had the highest usage rate of ME Online among all groups. T-tests revealed that first-generation students felt the videos were more enjoyable, helped them learn more, and made them more confident about their ability to succeed ( $p < 0.05$ ). Overall, it appears that students with the greatest potential for language challenges (i.e., first-generation) use ME Online more frequently, have a more favorable opinion of the resource, and feel this resource is more impactful ( $p < 0.10$ ). Focus groups and open-ended

responses indicate the ability to control the pace of lectures is particularly important among students for whom English is their second language or are learning a new language [17].

### 4.3 Suggestions to improve ME Online

The open-ended survey and focus group data provided feedback on aspects of ME Online that are working well for students, as well as suggestions for how ME Online could improve. Two major themes emerged.

#### *Add more videos on fundamental concepts and skills from math and physics courses:*

Engineering students complete most of their math and physics courses during the first two years of college, and these courses are usually taught by non-engineering instructors. Many of the fundamental concepts learned in those courses are not retaught by engineering instructors in their major courses – engineering instructors often assume students have gained a sufficient level of mastery even if the concepts were learned a few years prior. However, students said they need a refresher on many fundamental concepts, ideally from engineering instructors who can explain the concepts in a manner that is relevant to their engineering program. This aligns with research indicating engineering students benefit from supplemental videos in required physics courses [22].

#### *Add more videos on difficult, complicated, confusing topics, by a range of faculty in the major:*

Students saw the value in concepts being presented in different ways and indicated that they want “more than one professor per topic” because “everyone has a different style and the variety of learning may help students.” They felt that if they had “multiple professors to choose for each class” then they could find an instructor’s video that matched what they needed. “Some professors are easier/harder to understand and have different teaching styles.” As one student expressed:

“I generally promote these videos to other classmates. I really enjoy hearing explanations from other professors if I do not understand the material the first time. I've found myself struggling in vibrations this semester and really wishing that there were ME Online tutorials ... to help me understand the material.”

Students also wanted more videos for bottleneck (high enrollment, high failure rate) mechanical engineering courses, as well as videos on a wider range of topics beyond typical course material, such as preparation to become an engineering professional and preparation for licensing exams. They indicated more frequent and well-timed reminders about ME Online by faculty, email, and social media could help students become more aware of the video library.

## **5. Future work**

The ME Online video library will continue expanding into the foreseeable future as new videos are created by faculty in the Cal Poly Pomona Mechanical Engineering Department. The COVID-19 pandemic initially put a halt to the addition of new videos to the library as faculty members' attention was focused primarily on delivering their courses in the unfamiliar online format. However, in the long run the skills gained during the pandemic may facilitate a rapid growth in high-quality, accessible videos offered on ME Online, and this study will help the department with strategic planning on how to grow the library in future years. The pandemic already has resulted in the creation of dozens of procedural videos for lab courses which will be added to the library during 2021. These lab-related videos will both be a valuable resource for current students and showcase the hands-on nature of the program's curriculum. Indeed, the ME Online library currently is one of Cal Poly Pomona's largest sustained outreach efforts.

Increasing the number of videos available on ME Online will open opportunities for enhancing student success through new pedagogies (e.g., flipped classroom), increasing accessibility, boosting outreach, and allowing students to learn at a time and place of their choosing. As discussed in detail in Nissenon et al. (2019), the videos have been used in several pedagogical experiments including a flipped classroom version of a computer programming course and a fluid mechanics course [1], [29], [30], [31], [32], [33], [34], as well as a massive open online course [40], [41]. Additionally, the videos can add resiliency to the educational system if an emergency occurs, such as another pandemic or if a faculty member needs to work from home for personal reasons.

The ME Online video library was developed as a department-level effort for relatively low cost. Recently, the success of ME Online has led Cal Poly Pomona to attempt replicating the ME Online model with other departments. In Spring 2020, the authors led a faculty learning community where teams from four other departments learned how to make high-quality, accessible videos and create their own fledgling video libraries which have been collected together under a single university-level supersite [42]. Although this video tutorial supersite is still in its infancy, it has the potential to grow rapidly as each department's video library is maintained by its own faculty members (e.g., the Civil Engineering video library is maintained by Civil Engineering faculty), allowing the video libraries to grow in parallel. Details of the faculty learning community and the resulting video libraries will be published in the near future.

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