

GENDERED PERCEPTION OF ONLINE UNIVERSITY LEARNING OF STEM ENTREPRENEURSHIP DURING THE COVID-19 PANDEMIC

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Online educational experiences have exploded in popularity at the advent of the internet of things. Just as all forms before it, online learning has experienced implicit biases. With the abrupt lockdowns mandated by governments across the world, as a result of the COVID-19 pandemic, many educational institutions were thrust into an online learning environment with similarities and differences to the established online institutions already in place. Educational systems were forced to prepare and install methods of communication and instruction by using online resources such as online video calls and discussion forums. Here, we assess the impact of the COVID-19 pandemic on the Pre-Capstone Innovation Experience course at New York University, which provides entrepreneurship education in science, technology, engineering, and math (STEM) for undergraduates. Assessments captured between 2017 and 2020 from Pre-Capstone Innovation Experience participants demonstrate the gendered impact of the COVID-19 pandemic on the learning of undergraduate students.

Key words: Online learning; Gender differences; COVID-19

INTRODUCTION

In mid-March of 2020, the U.S. and many other countries around the world declared a lock-down that had immediate effects on day-to-day life for an entire population (1). Of lasting controversy was

how this would impact the education of millions of children at all ages. Reopening schools became a contested topic that weighed the importance of safety against childrens' well-being, including mental health, social progress, and learning loss (2,3).

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While concerns for increasing the spread of COVID-19 due to social interaction of children in schools was discussed (2,4), the less tangible damages, such as learning loss, were not well understood, and the lockdown policy reflected this as a necessary risk and potential loss (5). Specifically, studies have noted the dangerous impact of the pandemic on college students' mental health and school participation (6-8). One of the principal findings of these studies has been disengagement as a maladaptive coping mechanism (9). A recent study using longitudinal data of first-year college students has also shown an increase in anxiety and depression, which is specifically correlated with distance learning and social isolation and where the highest risk of increases in anxiety and depression were found in female and sexual/gender minority students (8).

Technology for remote learning already had strong infrastructure due to a growing popularity in remote options for conference calls and online courses. As a result, K-12 education and higher learning immediately transitioned to online conferencing options (10). The transition resulted in learning loss equivalent to the time that the online learning occurred (11). One of the key educational impacts resulting from economic and natural crises is learning loss (12,13). A lesser discussed matter has been how this educational transition may have a lasting and gender-biased impact (14). While there have been previous examples of gendered differences in online learning (15), it becomes more difficult to project the impact it will have as a result of the confounding variables associated with a crisis and online learning.

In 2016, we established the Convergence of Innovation and Entrepreneurship (CIE) (16) as an institute at New York University (NYU) with the mission to encourage innovation through inclusion and diversity and foster an environment for people of historically under-represented groups in science, technology, engineering, and mathematics (STEM) and entrepreneurship. As a part of this mission, and supported by Venturewell, we developed and implemented the Pre-Capstone Innovation Experience course, which was designed for our undergraduate engineering students. Surveys were given to students before and after the course to assess their learning of entrepreneurship and their feedback on their learning

experiences.

One of the goals of these surveys is to longitudinally assess gendered differences in entrepreneurship in STEM. In accordance with New York lockdown mandates, the 2020 Pre-Capstone Innovation Experience course transitioned to remote learning. Our survey captured the feedback of students as a result of both ranked and open feedback responses. Our data shows significant longitudinal trends in the course that are or are not influenced by the COVID-19 pandemic. Here, we compare these results with literature to gather an assessment of underlying gendered biases in online learning during the COVID-19 pandemic.

METHODOLOGY

We held Pre-Capstone Innovation Experience courses in 2017, 2019, and 2020. The course is designed for undergraduate engineering students in their sophomore/junior year and is aimed at preparing them for capstone/senior design projects. The course is accredited by NYU and counts towards a student's graduation. The underlying goals of the course are to 1) provide students with multidisciplinary engineering prototyping tools spanning biological engineering to circuit design; 2) expose students to the customer discovery process (17); 3) facilitate E-team formation and multidisciplinary groups; and 4) prepare students for both innovative capstone prototypes and their transformation into commercial ventures. The course operates by having students form teams after learning about engineering skills from three different engineering research disciplines: bioengineering, circuit design, and mechanical engineering. The teams then undertake ideation, customer discovery, and prototyping. Teams consist of two to four students each and are responsible for developing value propositions based on the problem they are aiming to solve. A pre-survey and post-survey assessing their progress and development is given before and after the course; participants' names are not used in survey analysis, and participants are made aware of the surveys' anonymity. While the surveys were explicitly optional, near full participation was seen among the cohorts. Importantly, the survey responses were collected through a Google Forms survey, which allowed a

student to participate online at their convenience. The data was analyzed by an independent researcher who did not participate in the classes and analyzed the data blind to name, gender, and race. We have collected survey responses for cohorts in Spring 2017, Fall 2019, and Fall 2020 (no course was held in 2018; see supporting information for survey). The survey is directed at understanding sociological trends among different groups of students, including gendered groups.

To assess gendered differences in online learning during the COVID-19 pandemic, we investigated the responses to the following questions.

Course participants were asked to rate their agreement with the following statements using one of these five responses: Totally Disagree, Somewhat Disagree, Neither Agree or Disagree, Somewhat Agree, and Totally Agree:

Overall, how would you describe the learning environment created during the course? Please choose the appropriate response for each item.

1. Productive
2. Innovative
3. Challenging (positively)
4. Collegial
5. Motivating
6. Stressful Harsh Exhausting

Our latest cohort, from 2020, was also asked how the COVID-19 pandemic and the hybrid environment during the COVID-19 pandemic had affected them.

Specifically, the following questions were added to the post-course survey in light of NYU's transition to online learning:

The open question:

1. Briefly describe the impact the learning environment (hybrid online course, teaching style, course structure, pace) has had on you and your team. You may elaborate on your responses to the above question.

In analyzing the data, a pattern emerged that allowed all responses to question 1 to be categorized based on the students' use of one of the following key words:

- a. Time Management
- b. Personal Development
- c. Interaction

A +1 was tallied for every positive comment using a key word and a -1 was tallied for every negative comment using a key word.

The rated questions asked participants to rate their agreement with the following statement using one of these five responses: Totally Disagree, Somewhat Disagree, Neither Agree or Disagree, Somewhat Agree, and Totally Agree:

2. The educational climate was conducive to learning.
3. The hybrid environment was conducive to a project course.

RESULTS AND DISCUSSION

Gendered differences in online learning have been studied in several world regions and student age groups (10,14,15,18-20). However, the studies come to contradictory conclusions. It is best summarized by Laube et al., "Some authors argue that gender-specific behavior patterns might discriminate and prevent women from using e-learning, while others contend that e-learning, through its flexible and interactive approach, supports women" (21). While some have concluded that gender shows no influence on the use of technology in learning (22), others have contended that female students are the beneficiaries of an online learning environment (19). Morante et al. conducted their own case studies, which interpreted Blackboard Learn data from a history class and a mathematics class, respectively (19). One of the most relevant conclusions was that female students who engage more with their learning environment achieve better results because they are more confident online than in face-to-face environments and more willing to learn and be self-directed (19). In the case of the latter, similar conclusions have been made from studies showing that female students tend to have stronger motivation and self-regulation (20).

Overall, from this literature review, conclusions on gendered advantage are unclear. It has been observed that female students have a greater tendency to display personality traits of self-direction and self-regulation that may be of a stronger benefit in an online learning environment (19,20). The wake of the pandemic seems to conservatively swing towards a perceived gendered disadvantage (23-25). The shift in positivity towards the learning environment in our course becomes clear in 2020 at the advent of the hybrid learning environment. This begs the question of how

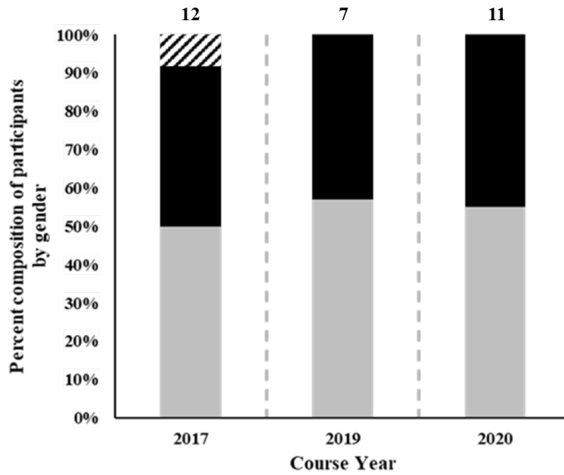


Figure 1. Cohort gender distribution by course year. Total number of participants are listed above the stacked bars per course year. Female is gray, male is black, and non-binary is striped.

the circumstances of a pandemic-induced transition to online or hybrid learning has caused a unique gendered outcome. Has the COVID-19 pandemic disproportionately affected female vs. male learning environments?

Participation in our pre-course and post-course surveys was highly encouraged (only one student did not participate in the survey in 2017). Figure 1 outlines the number of participants for each year’s cohort and its gender distribution.

In our study, some insights may be gained from the comments in the open questions. The students tended to discuss their experience using three key words: time, personal development, and interaction. In each category, male students responded to the key words in a more positive context than female students on average. Female students often commented negatively about a reduction in their ability to interact with fellow students in a hybrid course model. Male students tended to couple a negative comment about time management with a positive one in regards to personal development (Figure 2).

Female students mentioned reduced interaction as a negative impact of the hybrid transition, while male students did not mention this. Similarly, male students significantly (*p*-value 0.001) found that the transition impacted their personal development very positively compared to just slightly positively by female students. These results appear to agree with

previous studies showing the importance of interpersonal interaction in a learning environment for female students compared to male students (19). To control for the gender dynamics among the cohorts, the course teams were assessed by female gender make-up (Figure 3), where, importantly, each course year exhibited diversity in the gendered interaction of the teams, with some composed of all-male or all-female participants and some composed of some female and some male or some non-binary participants.

Additionally, male students found the course significantly more positively challenging. These results may help give direction to the negative perception of

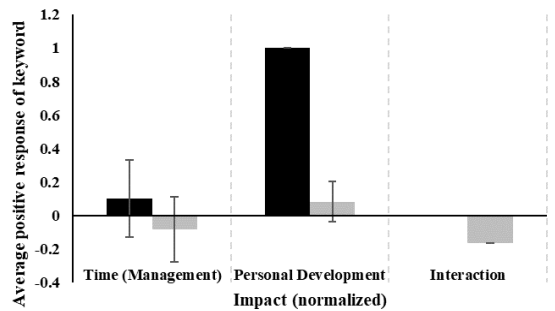


Figure 2. Gendered differences in response to hybrid transition as a result of COVID-19. Key words accumulated from open answers about the impact of the hybrid environment. Female is gray and male is black.

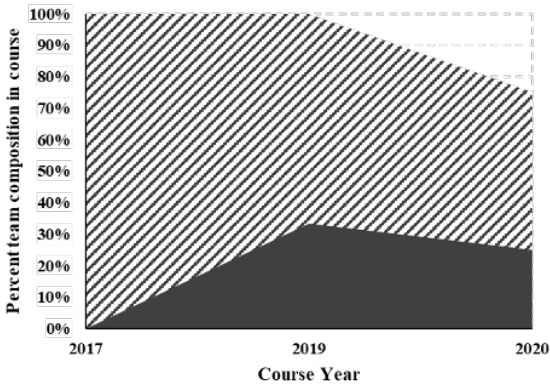


Figure 3. Gendered make-up of teams in each cohort shown as percent of teams. Teams of only female students is dark gray and teams with at least one female student is striped.

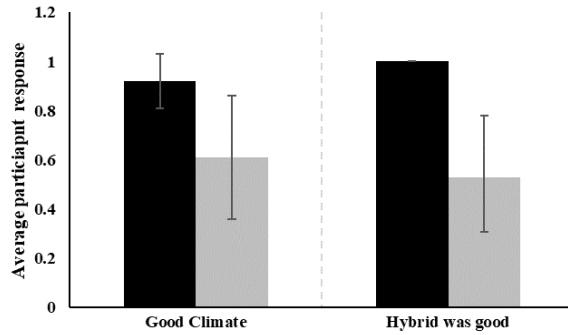


Figure 4. Participant responses by gender to the educational climate in general and whether the hybrid environment was conducive to a positive learning environment. Female is gray and male is black.

online transition during the COVID-19 pandemic. A less preferable learning environment during the pandemic may help explain the negative perception observed in our study. In the latest course, students were also asked about the online learning environment (Figure 4).

The results for whether the educational climate was conducive to learning or whether the hybrid environment was conducive to the project course indicated that the female students more negatively experienced the online learning environment and found the educational climate less conducive to learning (p -values 0.032 and 0.001).

When using survey questions that gauged the learning environment directly by asking if the environment was productive, innovative, or challenging, participant responses appear similar over time regardless of gender.

While conventional statistical significance is not shown in the trends between course years, female students show a decline in their perception of the course being positively challenging (p -value 0.17) and tend to respond more favorably to the learning environment compared to their male peers in 2017 and 2019 compared to 2020. In 2020, our course also surveyed students' perception of the learning environment with the additional positive descriptors: collegial and motivating, as well as the additional negative

descriptor: stressful harsh exhausting. A summary of all responses by gender in 2020 to the learning environment descriptors can be seen in Figure 8.

Here, the categories are ordered by increasing significance in the difference between the male and female averages using an unpaired t -test: 0.88, 0.58, 0.53, 0.53, 0.17, 0.02. A significant p -value is noted for the descriptor stressful harsh exhausting, where female students found the course significantly less stressful than male students. Thus, the stressful learning environment does not pair with how students felt about the hybrid and online learning environment. This may indicate that the online learning environment may provide other negative factors to the learning experience other than being stressful.

A unique quality of this study is its examination of the entrepreneurial interests of the participants (see supporting information), especially as they might relate to the learning environment. Students' interest in entrepreneurship was gauged by asking to what extent they agree with being interested in starting their own company versus working in a tech-based start-up, a distinction we felt might hinge on their desire to continue in STEM. The average responses on a scale of 'Totally Disagree' to 'Totally Agree' were recorded for each cohort (Figure 9 and Figure 10).

Using an unpaired t -test to evaluate the significance between male and female participants for

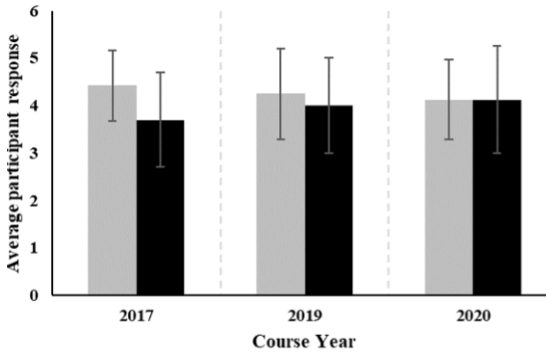


Figure 5. Rated student responses by gender for a productive learning environment (1 – Totally Disagree to 5 – Totally Agree). Female is gray and male is black.

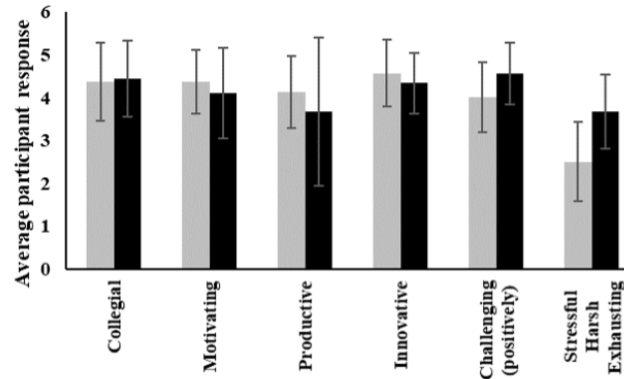


Figure 8. 2020 Participant responses by gender to questions assessing the learning environment. Female is gray and male is black.

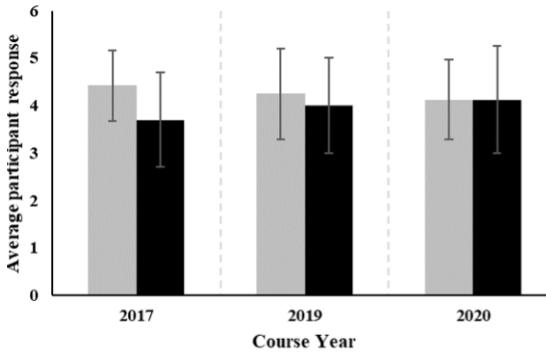


Figure 6. Rated student responses by gender for an innovative learning environment (1 – Totally Disagree to 5 – Totally Agree). Female is gray and male is black.

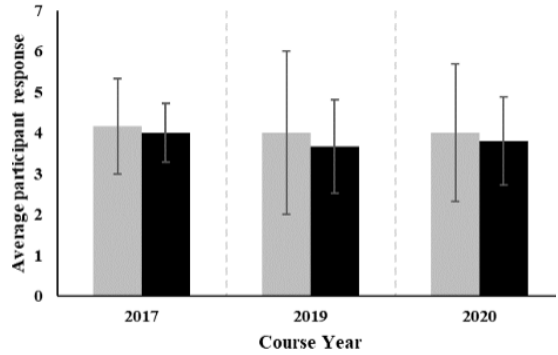


Figure 9. Participant responses by gender gauging their interest in starting their own company. Female is gray and male is black.

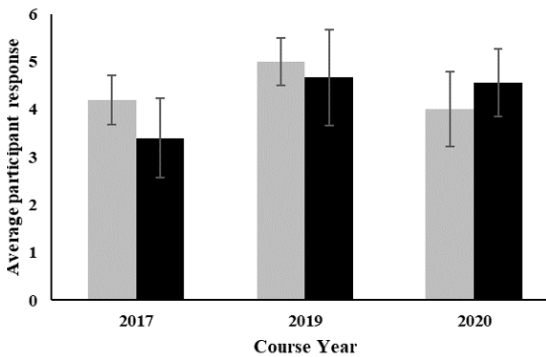


Figure 7. Rated student responses by gender for a challenging (positively) learning environment (1 – Totally Disagree to 5 – Totally Agree). Female is gray and male is black.

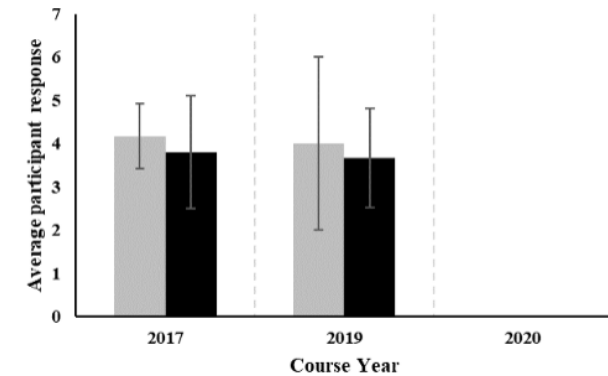


Figure 10. Participant responses by gender gauging their interest in working for a tech-based start-up. Female is gray and male is black.

the responses in both Figure 9 and Figure 10, high p -values were calculated, revealing little significance between the responses. From 2017 to 2020, p -values were 0.79, 0.81, 0.82 for Figure 8, and p -values were 0.57 and 0.81 for Figure 10 (this question was not asked in 2020). Similarly, while significance was not determined from the t -test, a consistent trend in responses is noted by female participants scoring their interest in entrepreneurship much higher than male students. This trend continued into 2020 as the pandemic forced a hybrid class transition. In pairing gendered differences in entrepreneurial interest and learning environment through the year 2020, it may speak to the isolated impacts of a pandemic on the perception of a learning environment over changes in the course or even disproportionate interest between genders and cohorts.

It may be natural to infer these trends are the result of the dominant effect of a crisis during the remote learning transition rather than the online learning environment itself. In circumstances of past crises, the impact of remote learning for students has been assessed through grades and surveys. Studies during these previous crises have shown that school closure has negatively affected student's learning. In fact, students' learning levels have significantly decreased and remain decreased for several years after reopening (13). Gendered differences have been reported previously for the COVID-19 pandemic, where males were found to report higher confidence in computer skills than female students in a study across multiple continents (26). Concerns of gendered learning differences as a result of the COVID-19 pandemic have been noted by the Center of Global Development in a cross-country survey in which educational responders felt that female students would be more adversely affected than male students due to reduced access to health services, less access to digital technology, and overall discouragement across various countries (23). Related reasons may be affecting female students more sharply in the U.S., as use of health services has gone down and the increased stresses of a more isolated culture may present an especially more negative social environment for females (24). The McKinsey Global Institute has pointed to many gender inequalities perpetuated by the COVID-19 pandemic that highlight the gap in stressors that have

predominantly affected women, including access to health and technology as well as employment (25). For example, their study has shown that 4.5% of women's employment was at risk due to the economic influences of COVID-19 compared to just 3.8% of men's employment globally.

CONCLUSIONS AND FUTURE WORK

The landscape of gendered differences in online learning has been discriminately inconclusive. Even as studies attempt to detail the differences, a gendered advantage is ambiguous at best. Here, general trends begin to reveal themselves by way of surveying students' perceptions of the learning environment over the years of our undergraduate course. In our study, female students report to having a more stressful learning environment despite other positive descriptors. They also note a negative perception of interpersonal interaction and personal development, qualities noted as important in a gendered difference study for online learning (19). Our hope is that with the continuation of the COVID-19 pandemic into the next academic year, more trends in these learning environments are able to be noted, especially as a face-to-face environment is being promoted in the U.S. In the future, studies that more directly assess the external effects of a pandemic on the educational environment might add to a story of a worsening online learning environment—one that had held benefits for female students previously—and lead to a positive course correction.

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