Examining the Impact of COVID-19 Pandemic on S-STEM Financially Supported Students' Change-Readiness and Self-Efficacy

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1. Introduction

S-STEM financially supported students: ETS-IMPRESS (The Engineering Technology Scholars – IMProving REtention and Student Success) participate in the Honors College Pathway Program (HCPP), where they write reflections frequently. All reflections are written and follow a "What/So What/Now What" format that instructors also describe as "Present, Analyze, What's Next?" This high impact practice (HIP) is used to help students process their experiences, gain perspective on them, and use them as a basis for future action. The benefits to students as a whole are growth in their ability to craft reflections and in their feelings of inclusion (as measured by the Longitudinal Assessment in Engineering Self-Efficacy (LAESE) survey instrument). Students find the program helpful in envisioning their future development, citing conversations with faculty and peers as essential in helping them consider their career options. Students in the "hands-on" fields of engineering technology see the benefits to reflective practices. Introducing regular reflection into their curricula can help their personal and professional development, and we all benefit from more thoughtful engineers. This study focuses on one previous literature by Fiss et al. [1], reporting challenges critical for ETS-IMPRESS students: having lower ratings in their change-readiness (e.g., optimism and adventurousness) and approaching a significantly lower rating on their self-efficacy (e.g., feeling of inclusion), compared to other honors students participating in the same Honors College Pathway Program. Based on these findings, we investigated ETS students' longitudinal responses in the areas of change-readiness, engineering self-efficacy, and intent to persist using three classic, validated surveys (Appendix A). We compared ETS students' first survey responses when they started to participate in HCPP with their latest responses in the program.

As shown by Pokhrel and Chhetri [2], students' social skills and professional skill development in education systems have been disrupted by the COVID pandemic. Lacking hands-on, laboratory experiences may lessen students' self-efficacy [3] and student confidence in pursuing a career goal may be reduced by decreased confidence in self-efficacy and professional skill development [4]. A research from the same university as our ETS scholars' also indicated that "providing meaningful practical experiences was a critical concern for both faculty and students" and students commented on their hand-on experiences during COVID transition as from "unexpected" to "unsustainable" [5]. Therefore, with the implementation of HIP reflection practice in HCPP, we would like to investigate whether the COVID-19 global pandemic may have had an impact on ETS students' professional skill development, such as their change-readiness, self-efficacy, and intent to persist. We then analyzed and visualized the results of the differences between the COVID time period and the Normal time period.

Overall, this paper provides an overview of two longitudinal design and analysis, including pre- and post-tests of student change-readiness and self-efficacy during their enrollment in HCPP. Primary research questions, research design and methodology, overall discussion of the experimental results, as well as conclusion and future directions are also included in this paper.

2. Examination of Students' Change-Readiness and Self-Efficacy across Different Time Periods

The goal of this project is to conduct a pretest/posttest and longitudinal study design to examine how student skill development outcomes change over time by measuring student self-efficacy, change-readiness, and intent to persist. These measures serve as a tool to better understand the experience of ETS students in engineering technology hands-on disciplines who are academically talented and financially underserved.

Research questions for this study are

Q1: How do students' change-readiness and self-efficacy change across different time points during their enrollment in HCPP using pre- and post-tests?
Q2: Is COVID-19 affecting S-STEM Scholars' change-readiness, self-efficacy, and intent to persist?

This study has undergone review and has been determined to be exempt by the university's Institutional Review Board.

3. Methodology and Survey Structure

We conducted one longitudinal study to address the first research question and the second research question.

3.1 Participants

There were 20 respondents (out of a total of 21 ETS-IMPRESS scholars) who responded to the questionnaires (95.45% response rate). Seventeen (94.44%) males and three (100%) females completed the entire survey. Participants' majors included electrical engineering technology, computer network & system administration, manufacturing and mechanical engineering technology, mechanical engineering technology, computer engineering, cybersecurity, and mechatronics.

Student responses (N=20) collected before they started HCPP serve as pre-test data to answer Q1. Among them, 14 students have enrolled in the HCPP seminars more than once and their last survey responses were used as post-tests. Regarding COVID and Normal time period comparison, 15 ETS students have completed the questionnaires at the Normal time period while 13 students have responded during the COVID time period. We define the COVID time period as when the university where the students resided announced the start of the pandemic and enforced facial covering mandates (3/16/2020) and ended with the announcement of moving to Health and Safety Level One when facial coverings were no longer required on campus (2/25/2022). The Normal time period can be traced back to Fall 2018 when we started to administer surveys, excluding the COVID time period.

3.2 Design and Procedure

We utilized a within-subjects design where all ETS students enrolled in the HCPP seminars complete three classic, validated questionnaires (Appendix A) multiple times during their undergraduate degree program. Students in the HCPP complete the questionnaires at the beginning of the HON1150, HON2150, and HON3150 seminars and when they complete the last seminar HON4150. To answer research Q1, ETS-IMPRESS students' first-time responses to the questionnaires are compared with their last-time responses to construct pre- and post-tests and determine whether their relevant skills have improved. We also compare ETS students' responses between COVID and Normal time periods to answer research Q2 and investigate whether COVID-19 has an impact on ETS students' change-readiness, self-efficacy, and intent to persist

SurveyMonkey, an online survey development cloud-based software, was used to administer the questionnaires. R programming language, a free statistical computing and graphics software, was utilized to manage, analyze, and visualize data.

3.3 Survey Structure

The questionnaires comprise three classic, validated surveys:

1) The Change-Readiness Assessment [6], which implements a 35-item scale to construct 7 categories, including adaptability, adventurousness, confidence, drive optimism, resourcefulness, and tolerance for ambiguity.
2) The Longitudinal Assessment in Engineering Self-Efficacy (LAESE) [7], which provides 30 questions to assess 6 subscales, including career success expectations, engineering self-efficacy I & II, coping self-efficacy, feeling of inclusion, and mathematics outcome expectations.
3) Persistence Measures [8], which uses 4 questions to measure 3 items, including career development, graduate study, and intent to change majors.

These questionnaires employed 7-point Likert scales, 1 referring to "not at all true of me" while 7 denoting "very true of me."

4. Analysis of Student Change-Readiness and Self-Efficacy Survey Data

4.1 Student Change-Readiness

4.1.1 Overall results and pre- & post-tests. The change-readiness results showed a trend that ETS students' scores had slightly increased from pre- to post-tests in areas of optimism, adventurousness, confidence, adaptability, drive, resourcefulness, and tolerance for ambiguity (Figure 1). There were no statistically significant differences between pre- and post-tests, according to Welch two-sample t tests. When looking into each item (Appendix A), no significant differences were found between any of the pre- and post-tests based on Welch two-sample t tests. In general, Students reported high means (scored 4 and above) in categories of drive and resourcefulness, while they reported low means (scored below 4) in optimism, adventurousness, confidence, adaptability, and tolerance for ambiguity in both pre- and post-tests (Figure 2). Among seven scales, tolerance for ambiguity had the lowest mean scores (M=3.23, SD=0.38); 75% and 64% of ETS students reported low means in pre- and post-tests, respectively.

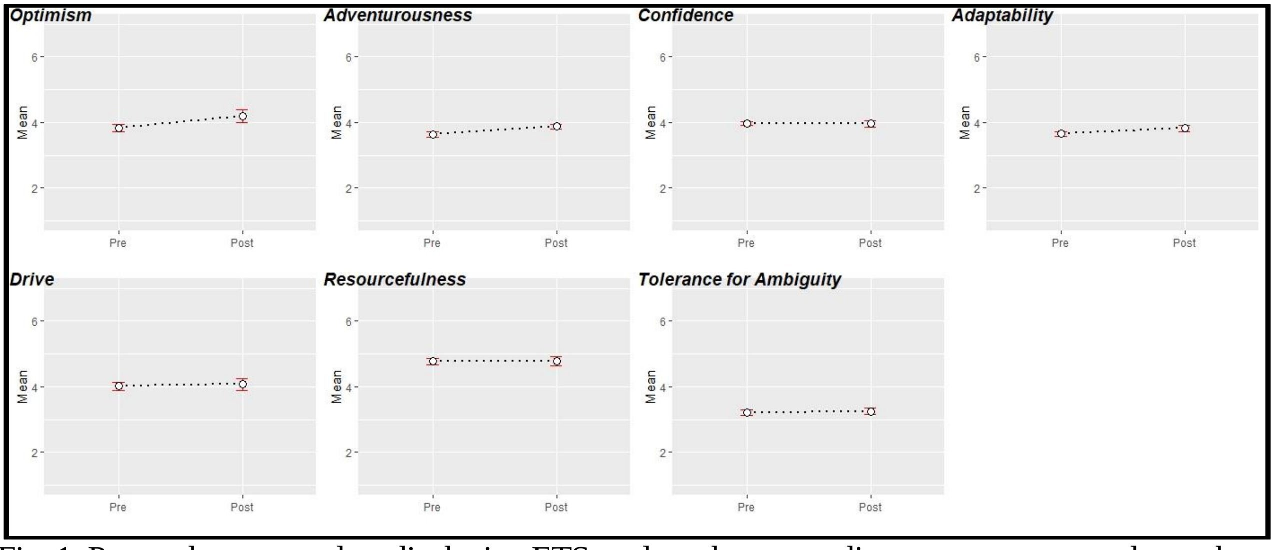

Fig. 1. Pre- and post-test plots displaying ETS student change-readiness mean scores and error bars in the categories of optimism, adventurousness, confidence, adaptability, drive, resourcefulness, and tolerance for ambiguity.

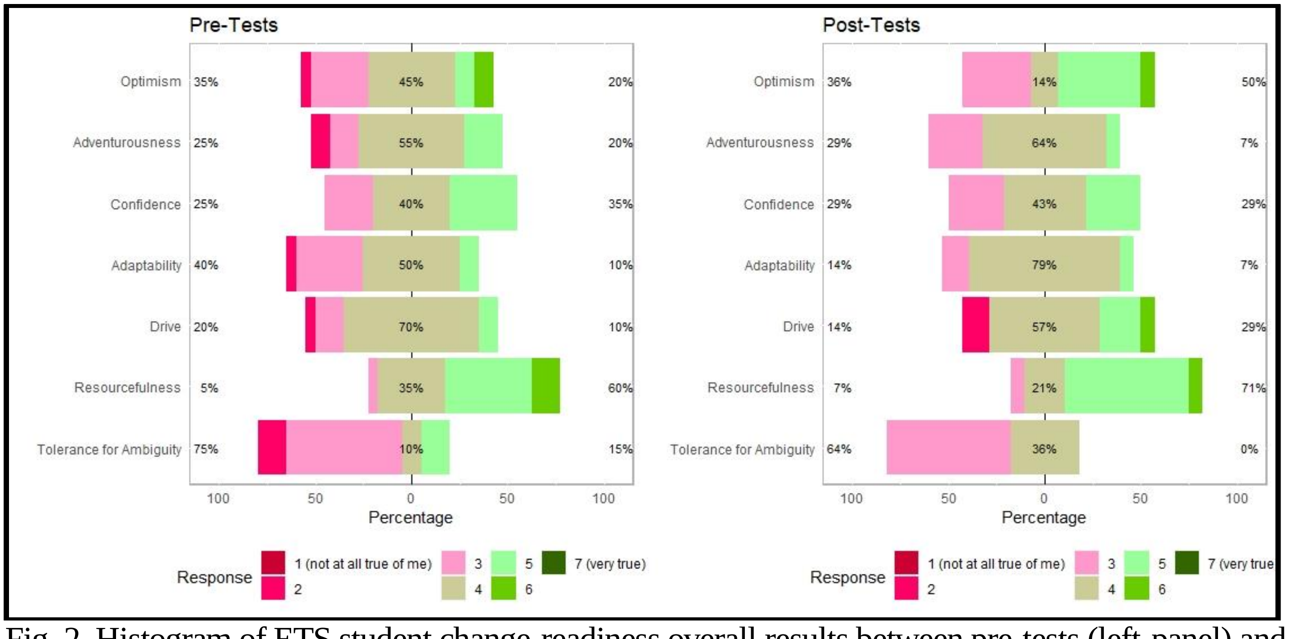

Fig. 2. Histogram of ETS student change-readiness overall results between pre-tests (left-panel) and post-tests (right-panel) in the categories of optimism, adventurousness, confidence, adaptability, drive, resourcefulness, and tolerance for ambiguity.

4.1.2. Comparison between COVID and Normal time periods. We further looked into longitudinal data of student change-readiness differences between two time periods, the COVID-19 time period (when University the students resided announced the start of the pandemic and enforced facial covering mandates) and the Normal time period (when facial coverings were not required on campus). An examination of ETS student change-readiness by COVID/Normal time periods reveals that there were no statistically significant differences between COVID and Normal time periods in any of the categories. However, the results showed trends similar to pre- and post-test analysis: most of the students reported high means in the measures of resourcefulness in both COVID and Normal time periods, while they reported low means in optimism, adventurousness, confidence, adaptability, and tolerance for ambiguity in both periods (Figure 3).

In addition, the results also showed trends that about 25% more students regarded themselves as having low tolerance for ambiguity, while 18% more students thought themselves as having low confidence, 7% more students considered themselves as having low optimism, and 2% more students reported themselves as having low resourcefulness during the COVID time period, compared to the Normal period.

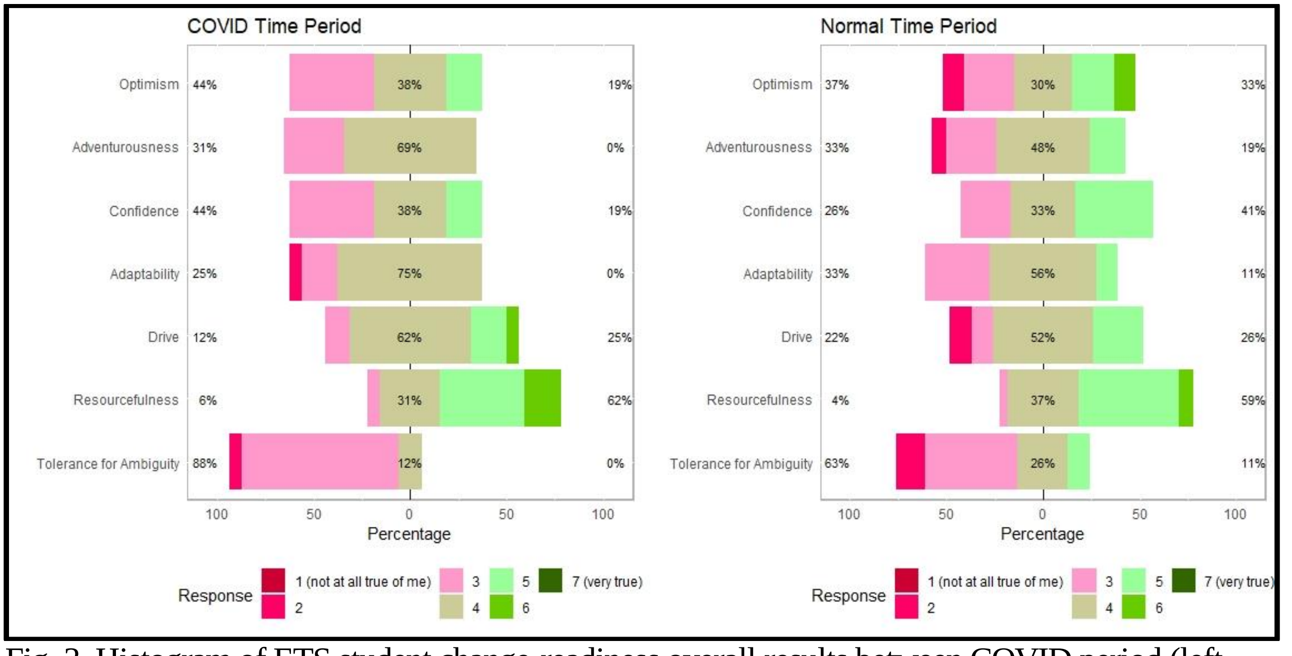

Fig. 3. Histogram of ETS student change-readiness overall results between COVID period (left-panel) and Normal period (right-panel) in the categories of optimism, adventurousness, confidence, adaptability, drive, resourcefulness, and tolerance for ambiguity.

When further looking into each question item (total N=35) under seven categories, the results depicted that ETS students scored significantly lower in student optimism item 1 (P=0.0246) and confidence item 3 (P=0.0112) in the COVID period than the Normal period (Figure 4). Student responses reflected their perception of low optimism and low confidence during the COVID transition as seen in Table 1.

Table 1. Welch two-sample t tests in student optimism, confidence, and tolerance for ambiguity in the COVID and Normal time periods (selected).

Factor/Question/ Item	Mean **COVID**	Mean **Normal**	95% CI Lower	95% CI Upper	t-test	df	p-value
Optimism 1: **I believe in not getting your hopes too high (Q5, reverse coded)**							
	2.63	3.37	-1.39	-0.10	-2.33	41	0.0246
Confidence 3: **I can handle anything that comes along (Q16).**							
	4.06	4.81	-1.32	-0.18	2.66	41	0.0112

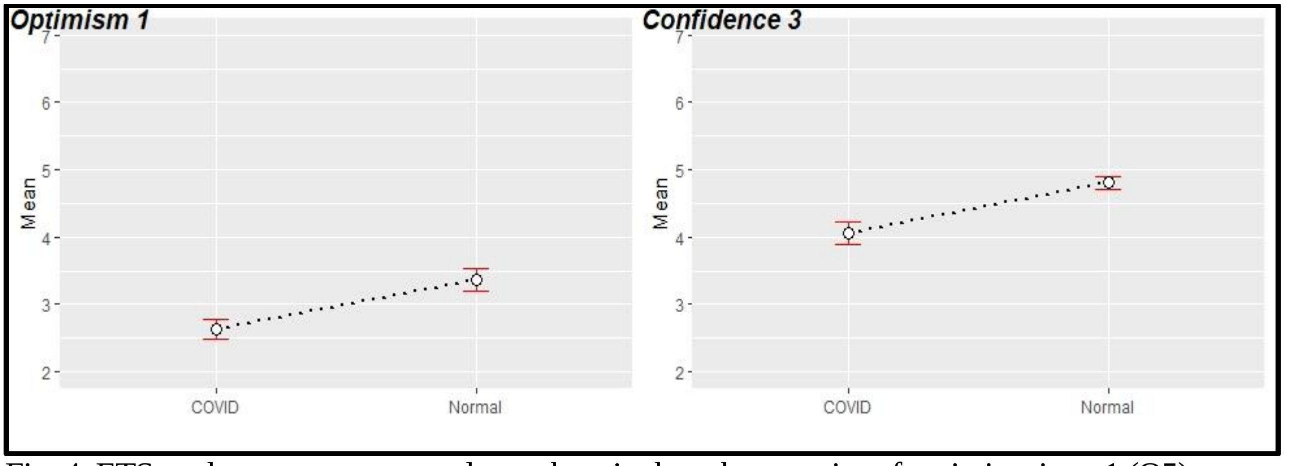

Fig. 4. ETS student mean scores and error bars in the subcategories of optimism item 1 (Q5), Confidence item 3 (Q16), and tolerance for ambiguity item 2 (Q14).

4.2 Student Self-Efficacy

4.2.1 Overall results and pre- & post-tests. In general, ETS students reported overall high means (scored above 4) on both pre- and post-tests on the measures of feeling of inclusion, coping self-efficacy, engineering career success expectations, engineering self-efficacy I & II, and mathematics outcome expectations (Figure 5). Though, it depicted a trend that ETS students' scores had slightly decreased from pre- to post-tests in all categories, it does not reach significant differences based on Welch two-sample t tests. In addition, no significant differences have been found between pre- and post-tests in any of the self-efficacy items. Moreover, feelings of inclusion had the lowest mean scores (M=5.02, SD=1.15) among all self-efficacy scales (Figure 6).

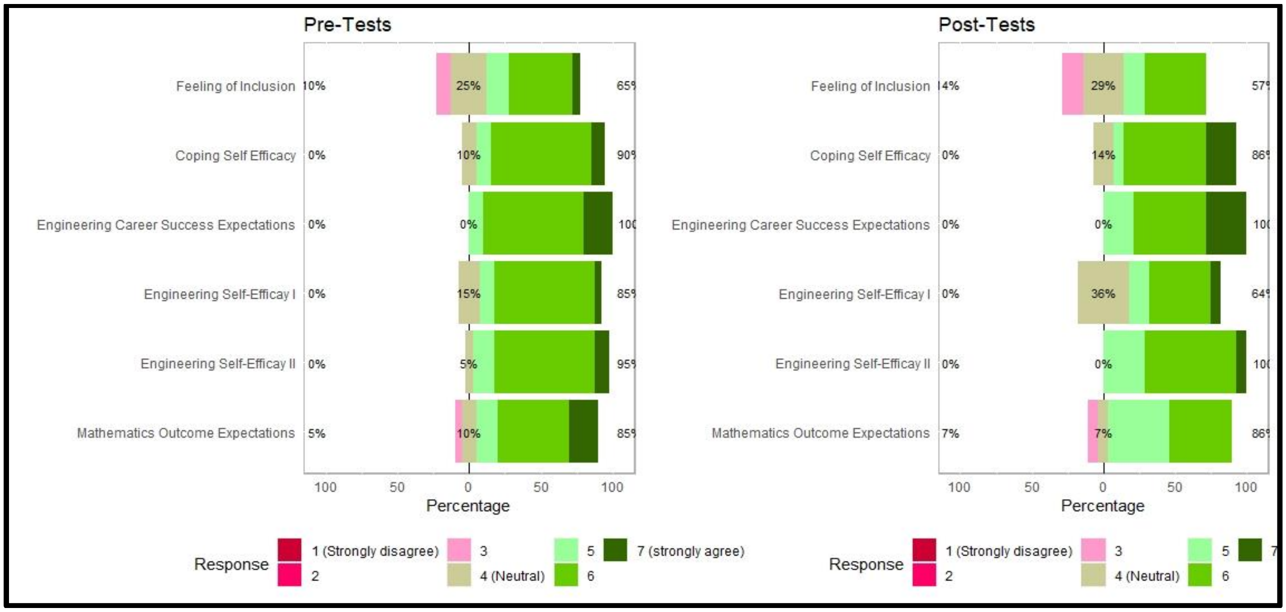

Fig. 5, Histogram of ETS student self-efficacy overall results between pre-tests (left-panel) and post-tests (right-panel) in the categories of feeling of inclusion, coping self-efficacy, engineering career success expectations, engineering self-efficacy I & II, and mathematics outcome expectations.

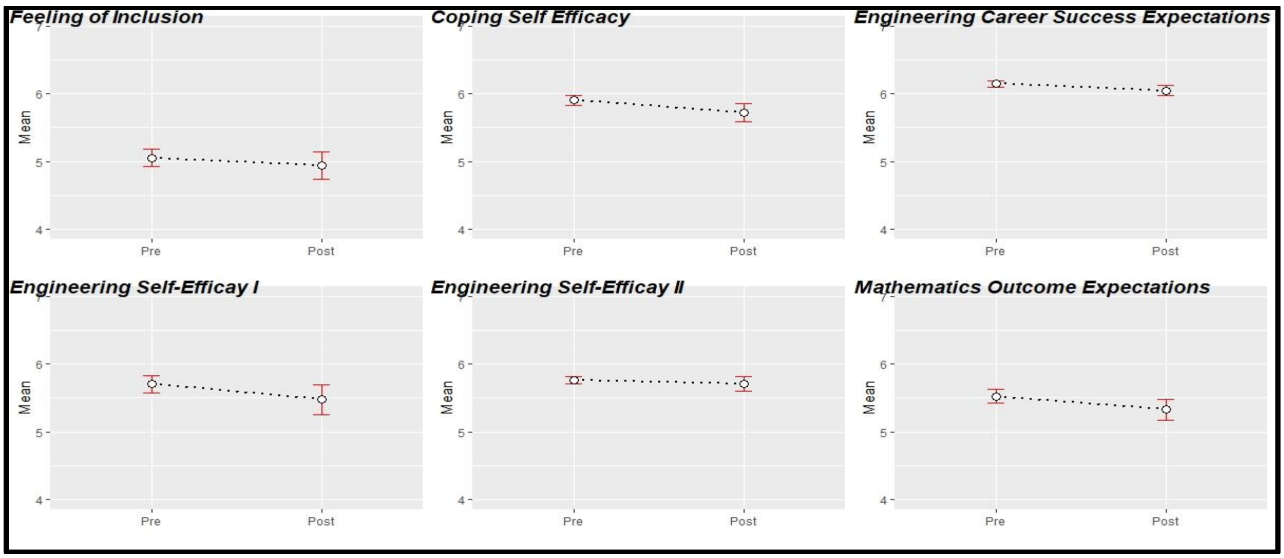

Fig. 6. Pre- and post-test plots exhibiting ETS student self-efficacy mean scores and error bars in six subscales.

4.2.2. Student self-efficacy comparison between COVID and Normal time periods. Further investigating student self-efficacy between COVID and Normal periods, an examination of ETS student self-efficacy by COVID/Normal period revealed that no significant differences were found in any of the categories. Students indicated high agreements on all categories in both COVID and Normal periods. In addition, the results also depicted patterns that about 15% more students considered themselves as having a high feeling of inclusion during the COVID time period, compared to the Normal period, revealing that COVID had no impact on student feeling of inclusion (Figure 7).

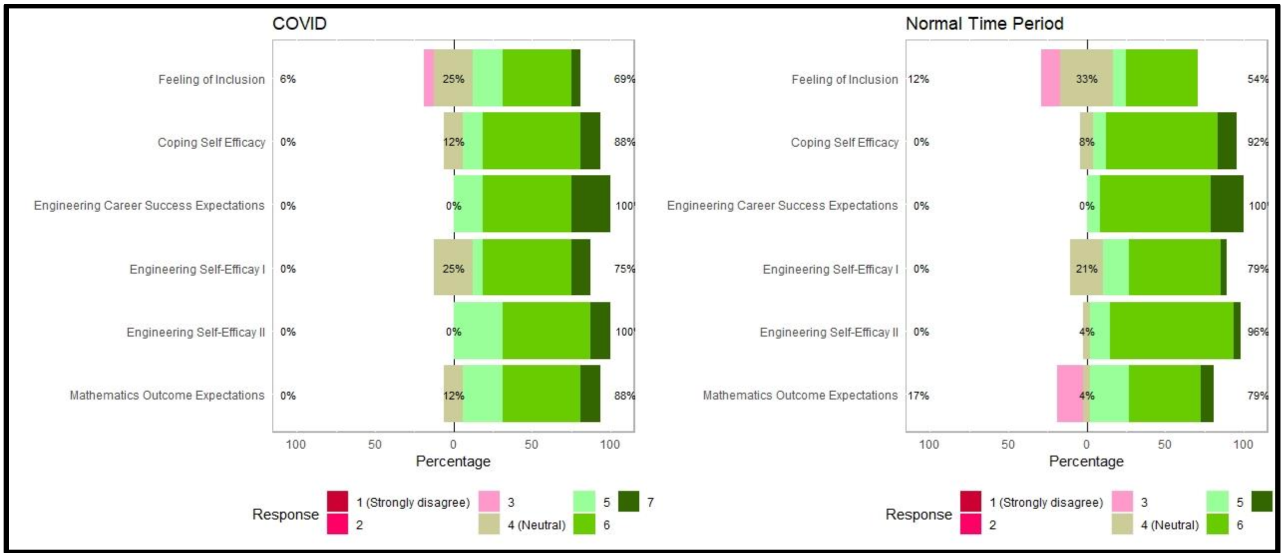

Fig. 7. Histogram of ETS student self-efficacy overall results between COVID (left-panel) and Normal (right-panel) time periods in six categories.

Furthermore, the results of the individual self-efficacy item (total N=28) showed that ETS students scored significantly lower in items under coping self-efficacy (P=0.0342), and engineering career success expectations (P_{ECSE1}=.0051 & P_{ECSE6}=0.0419) during the COVID time period than the Normal period (Figure 8). Student responses reflected their perception of decreased self-efficacy while attempting to get assistance from a faculty/staff and slightly decreased career expectation during the COVID period as shown in Table 2.

Table 2. Welch two-sample t tests in student self-efficacy in the COVID and Normal periods (selected).

Factor/Question/ Item	Mean **COVID**	Mean **Normal**	95% CI Lower	95% CI Upper	t-test	df	p-value
Coping Self-Efficacy 5: **I can approach a faculty or staff member to get assistance with academic problems (Q25).**							
	5.63	6.21	-1.12	-0.05	-2.20	38	0.0342
Engineering Career Success Expectation 1: **Someone like me can succeed in an engineering/technology career (Q4).**							
	6.13	6.65	-0.89	-0.17	-2.97	37	0.0051
Engineering Career Success Expectation 6: **A degree in engineering/technology will allow me to get a job where I can use my talents and creativity (Q22).**							
	6.06	6.46	-0.78	-0.02	-2.11	38	0.0419

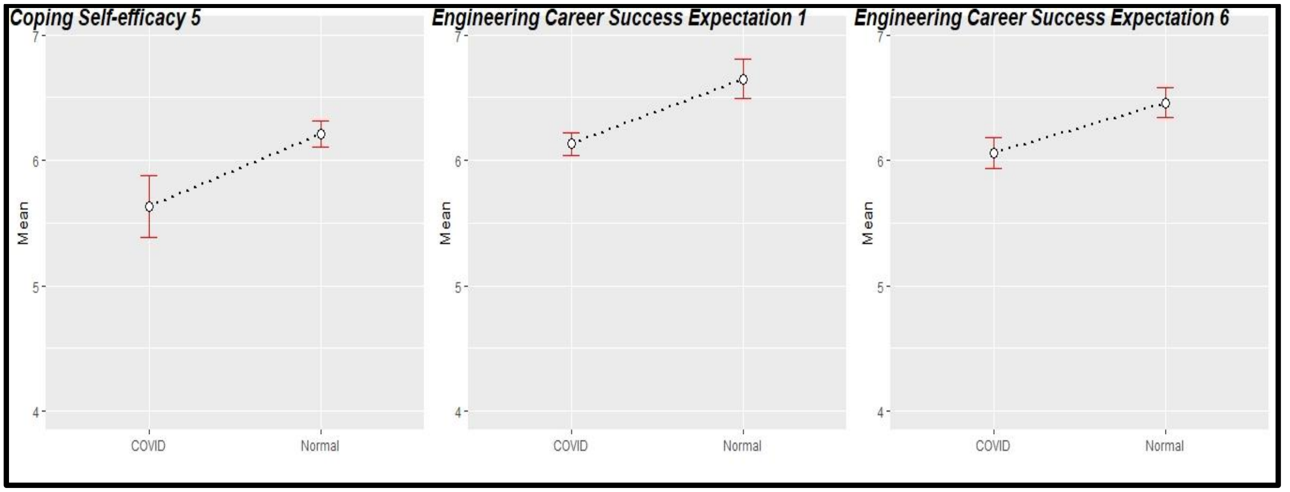

Fig. 8. ETS student mean scores and error bars in the subscales of coping self-efficacy item 5 (Q25) and engineering career success expectation items 1 (Q4) & 6 (Q22).

4.3 Student Intetnts to Persist

4.3.1 Overall results and pre- & post-tests. In general, ETS students across pre- and post-tests showed similar trends in their intentions to persist. Students reported their intent on connecting their future career with their majors, they stayed consistent regarding pursuing graduate study, and they were less likely to change their major (Figure 9). An analysis of student intentions to persist by time periods revealed that there were no significant differences between pre- and post-tests in the measures of career development, graduate study, and intent to change majors (Figure 10). Further investigating individual items (total N=5), no significant differences had been found in any of the subscales.

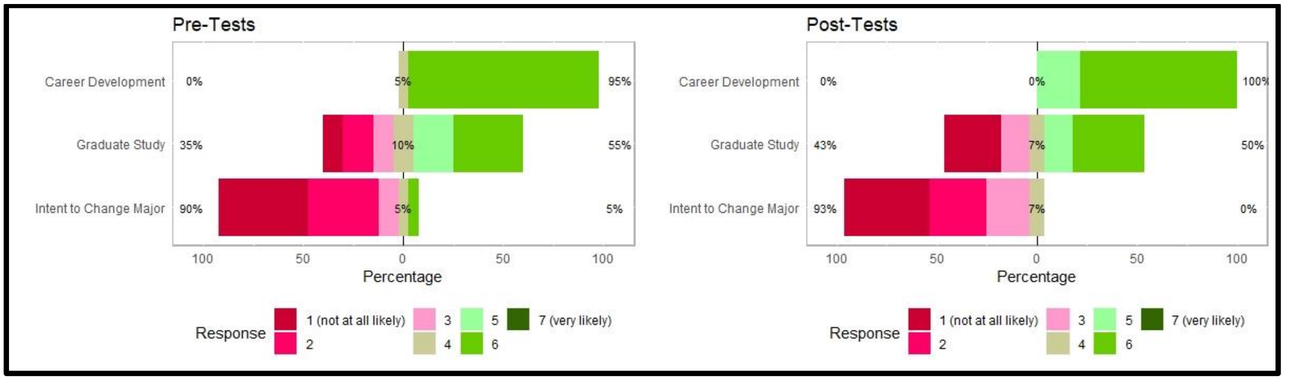

Fig. 9. Histogram of ETS student persistence overall results in pre-tests (left-panel) and post-tests (right-panel) time periods in three categories.

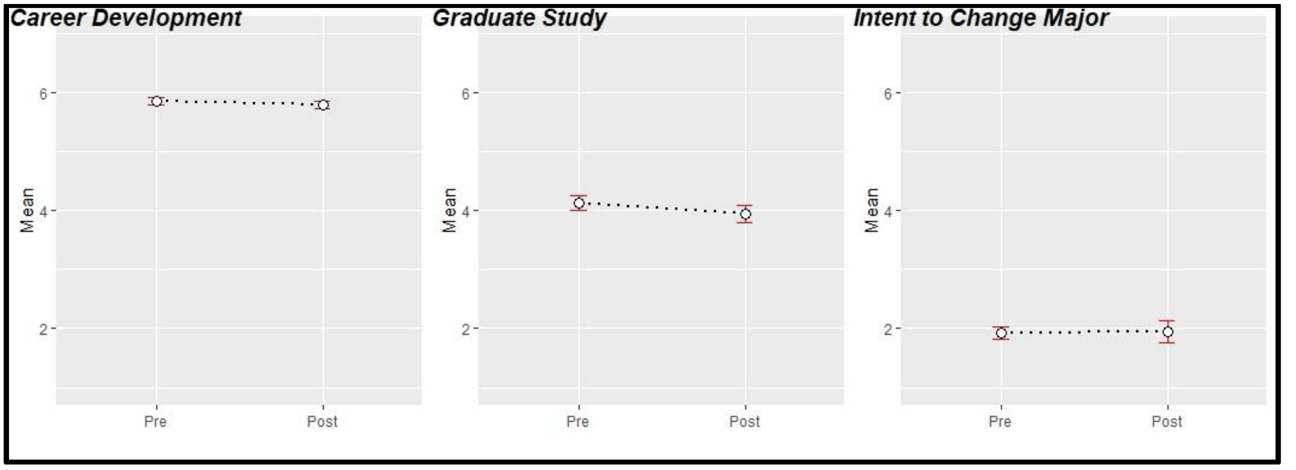

Fig. 10. Pre- and post-test plots exhibiting ETS student persistence mean scores and error bars in the categories of career development, graduate study, and intent to change major.

4.3.2. Student intents to persist comparison between COVID and Normal time periods. An analysis of student intents to persist by COVID/Normal periods showed similar trends in both COVID and Normal periods in that ETS students had high intention to pertain their career development with their current majors, about half of the students were insist in pursuing graduate study, and they had low intention to change majors (Figure 11). There were no significant differences between COVID and Normal periods in three scales and individual items, indicating that ETS students' career goals, graduate study, and majors remained steady across time as the pandemic unfolded.

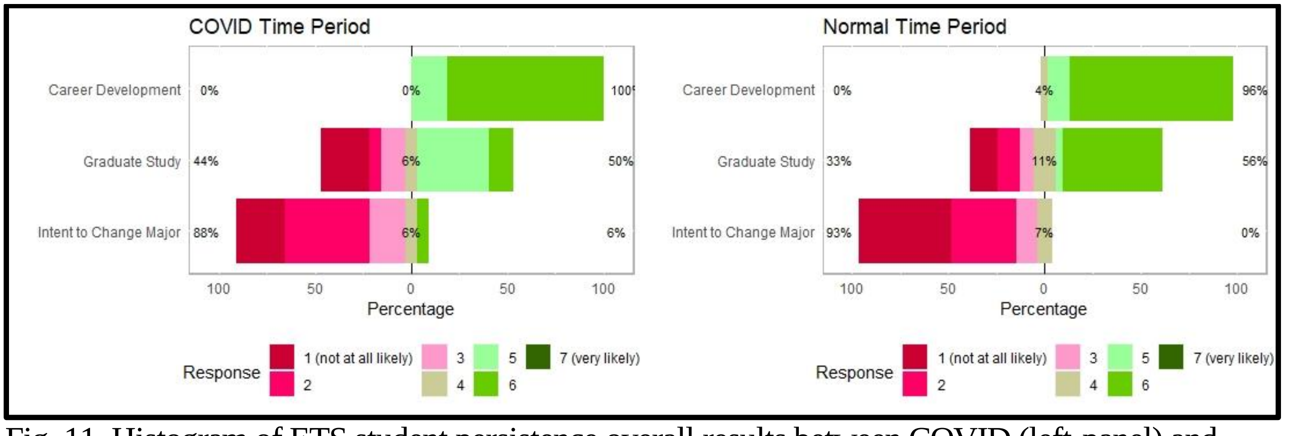

Fig. 11, Histogram of ETS student persistence overall results between COVID (left-panel) and Normal (right-panel) time periods in three categories.

5. Conclusion and Future Work

In general, the survey results showed no statistically significant differences in ETS student overall mean responses between first enrolling in HCPP program and exiting/last entry in HCPP (pre- and post-tests) in any of the surveying areas. Moreover, no significant differences between COVID and Normal periods were found, revealing that ETS students' career goals did not change across time during COVID, nor did their professional skills and self-efficacy. It is evident that immersing in reflection practice during the COVID pandemic helps students' professional skills stay consistent and show a trend of gradual improvement throughout their enrollment in HCPP. It is worthwhile to note that ETS students reported the lowest scores in the measures of tolerance for ambiguity (M=3.23, SD=0.38) and feelings of inclusion (M=5.02, SD=1.15) during the COVID pandemic, indicating that these are two primary skills students need to prepare when things are uncertain and/or challenge.

Furthermore, when we looked into subcategories, ETS students scored significantly lower in items such as student optimism (P=0.0246), confidence (P=0.0112), coping self-efficacy (P=.0342), and engineering career success expectations (P=.0051 & 0.0419) during the COVID period than the Normal period. ETS Student responses reflected their perception of the COVID transition. These include:

During the pandemic,

- students believe in not getting their hopes too high,
- it can be difficult for them to handle things as they come along,
- when they encounter academic problems, they may have some difficulty receiving faculty/staff assistance,
- students may harbor some doubts about their success in an engineering/technology career and using their talents and creativity to secure employment.

The limitations of this study are a small sample size and an unequal sample size in regards to gender, which may decrease the generalizability of the findings. In addition, participants were from a rural, mid-sized, science- and engineering-focused university, which may not be representative of students in an urban setting or at a larger more generally focused university.

As indicated above, for ETS students who majored in engineering technology hands-on disciplines, hands-on issues are one of their primary concerns [5]. Based on the survey results, we believe that reflection practice in HCPP not only increases student engagement and retention [1] and develops a "prototype of their future" [9], it is also a meaningful practical experience to students in STEM hands-on disciplines, especially when facing challenges throughout the COVID-19 pandemic. As a result, we plan to continue to utilize reflection as an HIP in support of today's S-STEM students and for similar challenges in the future.

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Biographies

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JOHN L. IRWIN is a professor for Mechanical Engineering Technology at Michigan Technological University, Dr. Irwin teaches courses in product design & development, statics and strength of materials, parametric modeling, and senior design. Research interests include STEM education, where, as PI for Improving Teacher Quality grants (2010 & 2013), he has developed and implemented professional development courses for K-12 science teachers to implement inquiry-based learning while utilizing computer simulations and 3D printing in their classrooms to help solve engineering problems.

Appendix A: Questionnaires Administered to ETS-Impress Scholars

1) Change-Readiness Assessment - Kriegel & Brandt, 1996			
Construct	No.	Items	Scales
a) Adventurousness	1	I prefer the familiar to the unknown. (REVERSED)	Likert Scale 1 (not at all true of me) to 7 (very true of me)
	8	I'm inclined to establish routines and stay with them. (REVERSED)	
	15	I prefer work that is familiar and within my comfort zone. (REVERSED)	
	22	It pays to stay with the tried and true. (REVERSED)	

	29	I prefer the main highway to the backroad. (REVERSED)	
b) Confidence	2	I rarely second guess myself.	
	9	I can make any situation work for me.	
	16	I can handle anything that comes along.	
	23	I focus on my strengths, not my weaknesses.	
	30	My faith in my abilities is unshakable.	
c) Adaptability	3	I'm unlikely to change plans once they're set. (REVERSED)	
	10	When something important doesn't work out, it takes me time to adjust. (REVERSED)	
	17	Once I've made up my mind, I don't easily change it. (REVERSED)	
	24	I find it hard to give on something even if it's not working out. (REVERSED)	
	31	When in Rome, do as the Romans do. (REVERSED)	
d) Drive	4	I can't wait for the day to get started.	
	11	I have a hard time relaxing and doing nothing.	
	18	I push myself to the max.	
	25	I'm restless and full of energy.	
	32	I'm a vigorous and passionate person.	
e) Optimism	5	I believe in not getting your hopes too high. (REVERSED)	
	12	If something can go wrong, it usually does. (REVERSED)	
	19	My tendency is to focus on what can go wrong. (REVERSED)	
	26	Things rarely work out the way you want them to. (REVERSED)	
	33	I'm more likely to see problems than opportunities. (REVERSED)	
f) Resourcefulness	6	If something's broken, I'll find a way to fix it.	
	13	When I get stuck I'm inclined to improvise solutions.	

	20	When people need solutions to problems, they call on me.	
	27	My strength is to find ways around obstacles.	
	34	I look in unusual places to find solutions.	
g) Tolerance for Ambiguity	7	I get impatient when there are not clear answers. (REVERSED)	
	14	I get frustrated when I can't get a grip on something. (REVERSED)	
	21	When an issue is unclear, my impulse is to clarify it right away. (REVERSED)	
	28	I can't stand to leave things unfinished. (REVERSED)	
	35	I don't perform well when there are vague expectations and goals. (REVERSED)	

2) The Longitudinal Assessment in Engineering Self-Efficacy (LAESE) – Marra & Bogue, 2006)			
Construct	No.	Items	Scales
a) Engineering Self-Efficacy I	2	I can succeed in an engineering/technology curriculum.	Likert scale 1 (strongly disagree) to 7 (strongly agree)
	6	I can succeed in an engineering/technology curriculum while not having to give up participation in my outside interests (e.g. extracurricular activities, family, & sports).	
b) Engineering Self-Efficacy II	8	I can complete the math requirements for most engineering/technology majors.	
	11	I can excel in an engineering/technology major during the current academic year.	
	13	I can complete any engineering/technology degree at this institution.	
	19	I can complete the physics requirements for most engineering/technology majors.	
	24	I can persist in an engineering/technology major during the next year.	
	28	I can complete the chemistry requirements for most engineering/technology majors.	
	4	Someone like me can succeed in an engineering/technology career.	

c) Engineering Career Success Expectations	10	A degree in engineering/technology will allow me to obtain a well-paying job.	
	12	I will be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter engineering/technology.	
	15	A degree in engineering/technology will give me the kind of lifestyle I want.	
	18	I will feel "part of the group" on my job if I enter engineering/technology.	
	22	A degree in engineering/technology will allow me to get a job where I can use my talents and creativity.	
	27	A degree in engineering/technology will allow me to obtain a job that I like.	
d) Feeling of Inclusion	1	I can relate to the people around me in my classes	
	3	I have a lot in common with the other students in my classes.	
	5	The other students in my classes share my personal interests.	
	7	I can relate to the people around me in my extracurricular activities.	
e) Coping Self-Efficacy	14	I can cope with not doing well on a test.	
	16	I can make friends with people from different backgrounds and/or values.	
	21	I can cope with friends' disapproval of my chosen major.	
	23	I can cope with being the only person of my race/ethnicity in my class.	
	25	I can approach a faculty or staff member to get assistance with academic problems.	
	26	I can adjust to a new campus environment.	
f) Mathematics Outcome Expectations	9	Doing well at math will enhance my career/job opportunities.	
	17	Doing well at math will increase my sense of self-worth.	
	20	Taking math courses will help me to keep my career options open.	

3) Persistence Measures - Schmader, Johns & Barquissau, 2004			
Construct	No.	Items	Scales
a) Graduate Study	36	How likely is it that you will pursue graduate study related to your major?	Likert Scale 1 (Not at all likely) to 7 (Very likely)
b) Career	37	How likely is it that your eventual career after graduation will directly pertain to mathematics or science?	
c) Intent to Change Major	38	How often do you think about changing your major?	Likert Scale 1 (Not at all) to 7 (Very Often)
	39	How likely is it that you will change your major	Likert Scale 1 (Not at all likely) to 7 (Very likely)