

STEM vs. Non-STEM Course Performance During COVID

Remote Learning in Higher Education

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INTRODUCTION

Objectives

- Investigate how student performance was affected during the stages of COVID remote learning.
- Determine if the effects were similar for STEM courses and Non-STEM courses at the 300 level

Data

- Fall 2019 – Spring 2021
- 300 level classes from various departments (see methodology for full list)
- 4000 rows of data
- 531 Different Courses
- Variables
 - Semester
 - Course ID
 - Course Subject
 - Course Number
 - Final Grade
 - Student Count
 - Instruction Method
 - Instructional Method Description

Assumptions

- Courses unchanged over time except for instructional mode
- Grades BLANK, F, I, IN, NC, WL, X.
- means unsuccessful completion of the course
- Outcomes were unaffected by
 - Course instructor
 - Class size

METHODOLOGY

- This project was IRB approved
 - Data was organized into STEM and Non-STEM courses based on Slippery Rock program guide.

Non-STEM		STEM	
Accounting	French	Physical & Health Education	Biology
Arabic	Hospitality and Tourism Management	Philosophy	Chemistry
Art	History	Political Science	Computer Science
Business	Homeland Security	Psychology	Cognitive Science & Leadership
Communication	Interdisciplinary Programs	Safety Management	Cybersecurity
Criminology & Criminal Justice	Japanese	Secondary Education/Foundations of Education	Environmental Geoscience
Corporate Security	Management	Spanish	Engineering
Dance	Marketing	Special Education	Exercise Science & Rehabilitation Science
Economics	Military Science	Sport Management	Geography/Environmental Science
English	Music	Theatre	Health Care Administration & Management
Finance	Philanthropy, Nonprofit, Leadership & Public Administration		Health Science/Public Health
			Industrial & Systems Engineering
			Mathematics
			Management Information Systems
			Nursing
			Parks & Conservation
			Physics
			Petroleum/Natural Gas Engineering
			Recreational Therapy
			Social Work
			Statistics

Data cleaning

- Grades coded as 0 due to unsuccessful course completion: BLANK, F, I, IN, NC, WL, X.
- Coded grades
 - P = 2.1 to be coded uniquely since passing grade is at least a C. There was not enough information to say this grade was anything higher than a C.

Letter Grade	Numerical Grade
A	4
B	3
P	2.1
C	2
D	1
F	0

- Removed variables after classification into STEM and Non-STEM:
 - Course ID
 - Course Subject
 - Course Number
 - Instruction Method
 - Instructional Method Description

Restructured data

- Separated data by semester
- Created a count variable which was the total number of each letter grade over each semester broken into STEM and Non-STEM
- Computed relative frequency variable for each semester for STEM and Non-STEM
- New data set contained letter grades, counts for each semester broken into STEM and Non-STEM, and Relative Frequencies for each grade for each semester broken into STEM and Non-STEM.

Descriptive Analysis

- Frequencies
 - Initial Frequencies per letter grade for each semester (STEM and Non-STEM) were investigated
- Graphs
 - Bar graphs of each semester's relative frequencies for STEM and Non-STEM
- Cluster Graphs
 - Non-STEM and STEM each semester
 - Non-STEM courses by semester
 - STEM courses by semester.

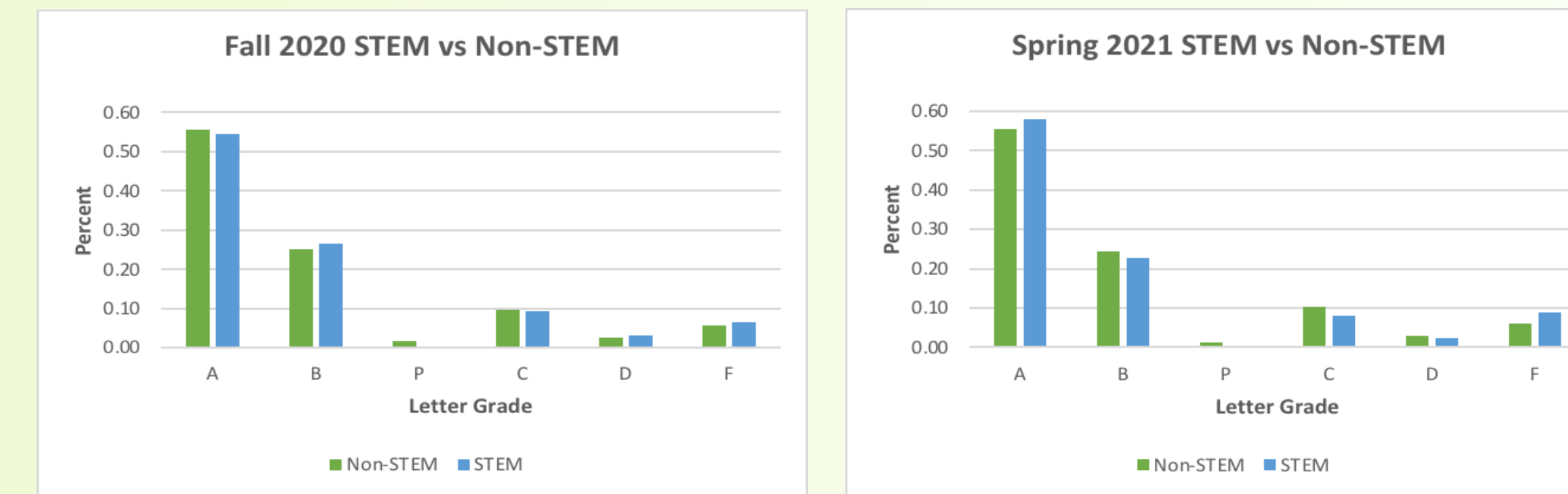
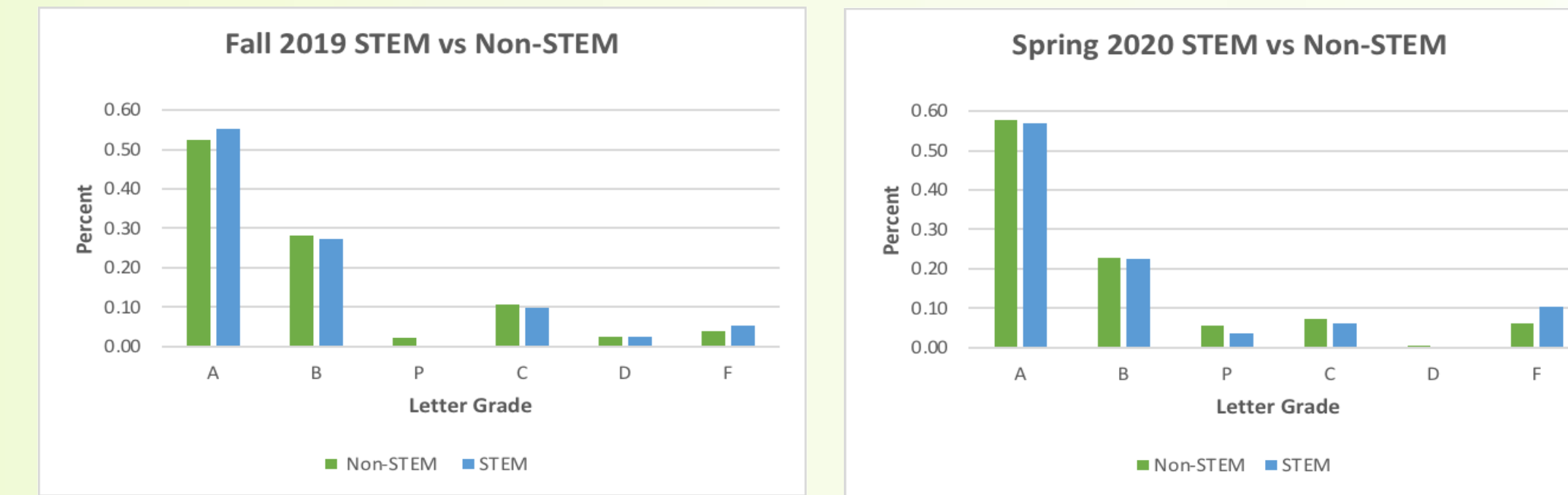
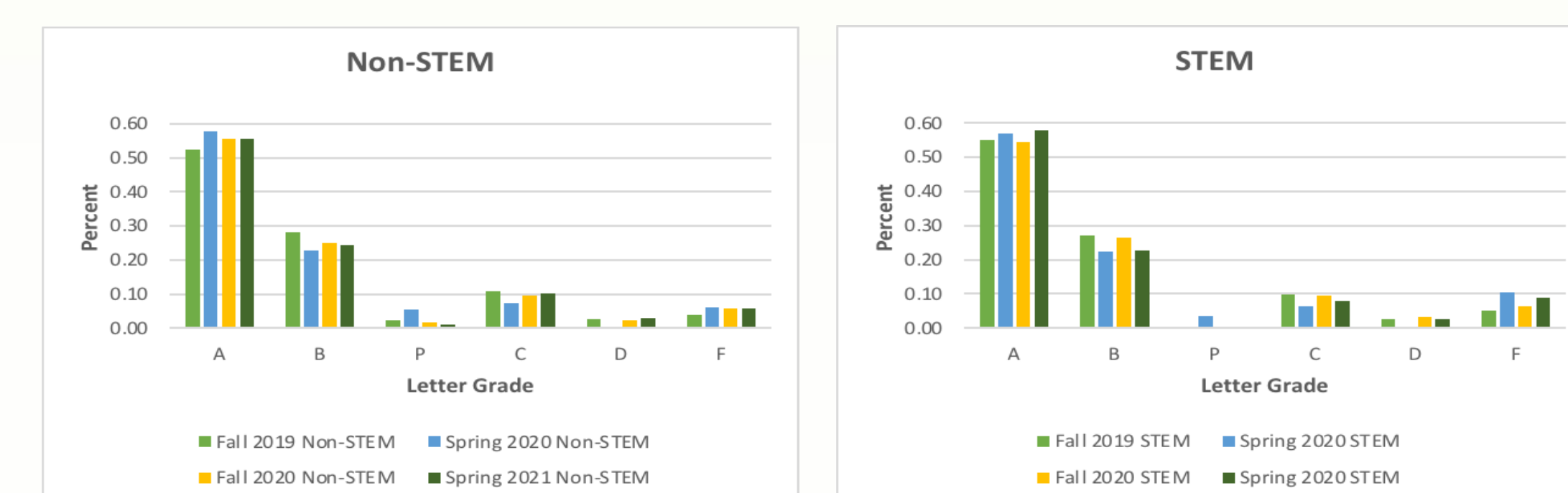
Inferences for Two Population Proportions $H_0: \hat{p}_1 = \hat{p}_2$

- $H_a: \hat{p}_1 \neq \hat{p}_2$ if H_0 rejected, $H_a: \hat{p}_1 < \hat{p}_2$ or $H_a: \hat{p}_1 > \hat{p}_2$ based on direction of sample proportions
- Test statistic $z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}_p(1-\hat{p}_p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$, where $\hat{p}_p = \frac{(x_1 + x_2)}{n_1 + n_2}$ with $\alpha = 0.05$
- Compare STEM and Non-STEM each semester
- Compare STEM and compare Non-STEM across all semesters with Fall 2019 as control
- Compare STEM and Non-STEM overall for all four semesters

Two Sample t-test for means with equal variances assumed

- $H_0: \mu_1 = \mu_2$ with $\alpha = 0.05$
- $H_a: \mu_1 \neq \mu_2$
- Test statistic $t = \frac{\bar{x}_1 - \bar{x}_2}{s_p \sqrt{1/n_1 + 1/n_2}}$ where $s_p = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2}}$ and $n_1 + n_2 - 1$ df
- Test for equal average grade for all STEM and Non-STEM comparisons

RESULTS AND DISCUSSION



	Fall 2019 Non-STEM n=2539	Fall 2019 STEM n=2454	Reject?	p-value	Conclusion
A	52.29%	55.09%	Yes	0.0088	NS < S
B	28.26%	27.18%	No	0.3114	Equal
P	2.21%	0%	Yes	0	NS > S
C	10.68%	9.97%	No	0.2816	Equal
D	2.53%	2.61%	No	0.8454	Equal
F	4.03%	5.22%	Yes	0.0071	NS < S
Mean	3.22	3.24	No	0.4511	Equal Average
Std.Dev.	1.03	1.08	No		

Equal proportions of B, C, and D. STEM had more A and F while Non-STEM had more P. STEM and Non-STEM have Equal average grades in Fall 2019.

	Spring 2020 Non-STEM n=2539	Spring 2020 STEM n=2454	Reject?	p-value	Conclusion
A	58.85%	56.92%	No	0.7764	Equal
B	22.80%	22.41%	No	0.4087	Equal
P	5.55%	3.62%	Yes	0	NS > S
C	7.40%	6.26%	No	0.0550	Equal
D	0.39%	0.34%	No	0.7064	Equal
F	6.03%	10.45%	Yes	0	NS < S
Mean	3.27	3.15	Yes	0	Unequal Average
Std.Dev.	1.09	1.26	Yes		

Equal proportions of A, B, C, and D. STEM had more F and Non-STEM had more P. STEM and Non-STEM have unequal average grades in Spring 2020.

	Fall 2020 Non-STEM n=2464	Fall 2020 STEM n=2285	Reject?	p-value	Conclusion
A	55.45%	54.40%	No	0.3869	Equal
B	25.06%	26.61%	No	0.1407	Equal
P	1.74%	0%	Yes	0	NS > S
C	9.53%	9.45%	No	0.9144	Equal
D	2.48%	3.15%	Yes	0.04199	NS < S
F	6.70%	6.39%	No	0.2942	Equal
Mean	3.22	3.19	No	0.3423	Equal Average
Std.Dev.	1.11	1.14	No		

Equal proportions of A, B, C, and F. STEM has more D. Non-STEM has more P. STEM and Non-STEM have Equal average grades in Fall 2020.

	Spring 2021 Non-STEM n=2135	Spring 2021 STEM n=3032	Reject?	p-value	Conclusion
A	55.40%	57.85%	Yes	0.0132	NS < S
B	24.50%	22.69%	No	0.0562	Equal
P	1.14%	0%	Yes	0	NS > S
C	10.17%	8.01%	Yes	0	NS > S
D	2.87%	2.51%	No	0.3184	Equal
F	5.92%	8.94%	Yes	0	NS < S
Mean	3.21	3.18	No	0.2947	Equal Average
Std.Dev.	1.13	1.24	No		

Equal proportions of B and D. STEM has more A and F while Non-STEM has more P and C. STEM and Non-STEM have Equal average grades for Spring 2021.

	Fall 2019-Spring 2021 Non-STEM n=25133	Fall 2019-Spring 2021 STEM n=10422	Reject?	p-value	Conclusion
A	56.29%	56.21%	No	0.0824	Equal
B	25.19%	24.53%	No	0.1939	Equal
P	2.63%	0.92%	Yes	0	NS > S
C	9.47%	8.33%	Yes	0	NS > S
D	2.08%	2.12%	No	0.8124	Equal
F	5.43%	7.89%	Yes	0	NS < S
Mean	3.23	3.19	Yes	0.0038	Unequal Average
Std.Dev.	1.09	1.19	Yes		

Overall, from Fall 2019 through Spring 2021, STEM students and Non-STEM students earned equal proportions of A, B, and D. Non-STEM students earned more P and C, and STEM students earned more F. Unequal average grades.

	Non-STEM with Fall 2019 as control		
	Spring 2020	Fall 2020	Spring 2021
A	Increase	Increase	Increase
B	Decrease	Decrease	Decrease
P	Increase	Decrease	Decrease
C	Decrease	Decrease	Equal
D	Decrease	Equal	Equal
F	Increase	Increase	Increase

In Spring 2020, Non-STEM students earned more A, P, and F and fewer B, C, D than Fall 2019.

In Fall 2020, Non-STEM students earned more A and F and fewer B, P and C than Fall 2019.

In Spring 2021, Non-STEM students earned more A and F, fewer B and P than Fall 2019. Students earned equal portion of C and D. All statistical conclusions were significant.

	STEM with Fall 2019 as control		
	Spring 2020	Fall 2020	Spring 2021
A	Equal	Equal	Increase
B	Decrease	Equal	Decrease
P	Increase	N/A	N/A
C	Decrease	Equal	Decrease
D	Decrease	Equal	Equal
F	Increase	Equal	Increase

In Spring 2020, STEM students earned more P and F, fewer B, C, and D, and equal portion of A than in Fall 2019.

In Fall 2020, STEM students earned equal portions of A, B, C, D, and F as in Fall 2019.

In Spring 2021, STEM students earned more A and F, fewer B and C than Fall 2019. Students earned equal portion of D. No P grades were earned in Stem courses in the Spring 2021 academic semester.

All statistical conclusions were significant.

LIMITATIONS

- Data was letter grades – more analysis could have been completed with quantitative percent grades, which are not accessible.
- Unable to incorporate other confounding factors that may have influenced course grades such as student health and student circumstances.
- Number of semesters available in data

CONCLUSION

The results of the two sample mean t-test for equal variances show that the average grades of 300-level STEM and Non-STEM courses are equal for Fall 2019, Fall 2020, and Spring 2021. This indicates that student grades in STEM courses were equivalent to student grades in Non-STEM courses in 300-level courses each of those three semesters, regardless of the modality of instruction. Additionally, the average grade was higher in Non-STEM courses than STEM courses during the Spring 2020 semester, indicating that STEM students were impacted more than Non-STEM students during the semester that instruction switched from in-person to online. In general, students in both STEM and Non-STEM courses earned more A and F grades throughout online learning and fewer average grades than the last in-person semester of Fall 2019. Prior to COVID-remote learning and during the fully online learning, STEM and Non-STEM student grades were not significantly impacted in comparison to one another each semester. Overall, remote learning did not significantly impact the average grade distribution for STEM and Non-STEM courses except during the semester of transitioning to online learning, where STEM grades were more negatively impacted.

FUTURE WORKS

- Compare pre-COVID online to during and post COVID online
- Same study comparing departments
- Investigate 100 and 200 level courses
- Investigate Graduate level courses