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Board 436: Work in Progress: Testing and Examining the Impact of a Set of STEM-Oriented Creative Video Projects on STEM Students' Psychosocial, Persistence, and Scholastic Outcomes

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Testing and Examining the Impact of a Set of STEM-Oriented Creative Video Projects on STEM Students' Psychosocial, Persistence, and Scholastic Outcomes (In-Progress)

Abstract

This project is being conducted by Texas A&M International University (TAMIU); a Hispanic-serving institution in the U.S. southern border city of Laredo, Texas. The project has a programmatic and a research component; it focuses on generating knowledge about strategies to enhance undergraduate science, technology, engineering, and mathematics (STEM) education. The programmatic component aims to increase the quantity and improve the quality of retained and graduated STEM students. This is done by engaging 3 consecutive cohorts in a 4-semester pre-/early college (i.e., pre-college summer and freshman fall/spring/summer semesters) curriculum-based STEM-enrichment program called USTEM. USTEM implements high-impact and proven STEM-enrichment activities, practices, and strategies that have been published in the literature. The research component studies how an original set of creative video projects (CVPs) influences students' psychosocial, scholastic, and persistence outcomes. This study entails randomizing half of each cohort to participate in USTEM without CVPs (USTEM1) and the other half to participate in USTEM with CVPs (USTEM2). USTEM2 participants produce four CVPs: 1) a biography of a STEM scientist, 2) a position statement on a STEM controversy, 3) a tutorial on a STEM topic, and 4) a critique of a STEM peer-reviewed research article. Outcomes are measured at every end-of-semester. The generated data allow for evaluating the efficacy of USTEM2 versus USTEM1 and the parametric characterization of trends across semesters. In this report, we present preliminary results generated from five completed measurement occasions (M1-M5) for Cohort 1 (at M1: USTEM1, n=22; USTEM2, n=19) and Cohort 2 (at M1: USTEM1, n=12; USTEM2, n=17) vis-à-vis five PSO indicators: 1) academic self-efficacy in STEM (ASESTEM; an average of 3 items), 2) self-efficacy in performing STEM tasks (STEMTaskSE; an average of 4 items), 3) sense of belonging in STEM (STEMSB; an average of 18 items), 4) STEM self-identity (STEMSI; an average of 4 items), and 5) sentiments about staying in a STEM major (STEMstay; an average of 2 items). Deployed online, each of the five PSO indicators comprises 7-point Likert-scaled items adopted from the extant literature on STEM education. From our preliminary results, we discovered that the timing of measurements has a noticeable impact on PSOs. However, we did not observe significant differences between cohorts or comparison groups (there was no clear distinction between USTEM1 and USTEM2). Our findings suggest that USTEM participants experience an improved sense of belonging during pre-college and freshman summer camps, which are more relaxed times that may have provided opportunities for participants to bond with old and new friends. However, we observed a decline in academic self-efficacy and intention to stay in STEM during the freshman fall semester. This could be due to the combined effect of participants' first-time exposure to college-level STEM courses, a new social environment, and the demands of college life. It is important to note that we are still collecting data for Cohort 3, and we will update our results once these data are included in our analyses.

Keywords

STEM Sense of Belonging, STEM Self-Efficacy, STEM self-identity, Creative Video Projects, Persistence, Retention

1. Background

We present preliminary results from our research conducted at Texas A&M International University (TAMIU), a Hispanic-serving institution located along the U.S.-Mexico border. Our study focuses on generating knowledge about learning strategies that improve and enhance undergraduate STEM education. As such, our study has both a programmatic and a research component. Through our project's *programmatic component*, we aim to increase the quantity and improve the quality of retained and graduated TAMIU STEM students. We will engage three consecutive cohorts (one cohort per year) of students in a 4-semester pre-/early-college (i.e., pre-college summer and freshman fall/spring/summer semesters) curriculum-based STEM-enrichment program called USTEM.[1] Through USTEM, we implement high-impact and proven STEM-enrichment activities, practices, and strategies published in the STEM education literature. These activities, practices, and strategies involve a pre-college summer camp (PCSC), a Research Method I (RM-I) course, a Research Methods II (RM-II) course, and an undergraduate research experience (URE).

Through our project's *research component*, we examine how a set of creative video projects (CVPs) that we designed influences students' psychosocial outcomes (PSOs). These PSOs are 1) a sense of belonging in STEM (feelings of membership or acceptance in STEM), 2) STEM self-efficacy (confidence in one's ability to be successful in STEM), and 3) STEM identity (the mindset that the norms and values of STEM importantly define one's self-image)[1-4]. CVPs, particularly involving groups of students who must evaluate and synthesize information for intentional and creative dissemination, offer a valuable form of active experiential and collaborative learning [5, 6]. This form combines several high-impact educational practices proven to enhance student learning outcomes [7]. Our study is innovative as there is little scholarship on using CVPs in STEM-enhancement programs, so CVPs were chosen as our intra-curricular activities.

The intellectual merit of our study derives from our use of 1) *randomized controlled trial format*, *blocking* and *replication* techniques, and *generalized randomized block design* (GRBD) to enhance internal validity and minimize extraneous variation [2, 8, 9] ; 2) longitudinal analytical techniques to examine trends in persistence, scholastic, and psychosocial outcomes[10]; and 3) empirically validated and target-population-calibrated instruments to ensure our indicators' reliability, reproducibility, and validity. Once data collection is completed and analyzed, the results and products of this 3-year experiment will advance a fundamental understanding of how STEM-oriented CVPs influence psychosocial and scholastic outcomes and, ultimately, persistence in STEM.

2. Research Design

TAMIU's Institutional Review Board has approved our study protocol (IRB #2020-04-15). As part of our IRB protocol, we adhered to ethical standards by providing potential participants with detailed information about our study. However, we were careful not to reveal the hypotheses or predicted outcomes to maintain the integrity of the research. Once we obtained signed consent from participants (parental consent and participant assent, in the case of participants under 18 years

[1] As of this reporting, we have completed data collection for Cohort 1 and 2. Data collection for Cohort 3 will be completed by July 2024.

of age), they were randomized to the comparison groups described below. We treated participants' survey responses as confidential and did not reveal identifiable information in our analyses and reports.

In our RCT in GRBD longitudinal experiment, each cohort is cast a *block,* and participants serve as *replications* within each block. We randomly assign half of each cohort to participate in USTEM without CVPs (USTEM1), while the other half participates in USTEM with CVPs (USTEM2). USTEM2 participants produce four videos: 1) a biography of a STEM scientist (CVP1; e.g., "*The Life of Lise Meitner*"); 2) a position statement on a STEM controversy (CVP2e.g., "*Should the U.S. continue manned space exploration*?"); 3) a tutorial on a STEM technique (CVP3; "*What are orthogonal contrasts and degrees of freedom*?"); and 4) a methodological critique of a STEM peer-reviewed research article (CVP4; e.g., *critiquing the experimental plan of a research article in Science Magazine*).

USTEM1 and USTEM2 engage in PCSC, RM-I, RM-II, and URE. In addition, USTEM2 also engages in CVP1, CVP2, CVP3, and CVP4. These activities are arranged in a timeline as follows: During the summer before college, USTEM1 does PCSC, while USTEM2 does PCSC and CVP1. In the fall semester of freshman year, USTEM1 does RM-I, while USTEM2 does RM-I and CVP2. In the spring semester of freshman year, USTEM1 does RM-II, while USTEM2 does both RM-II and CVP3. During the summer after freshman year, USTEM1 does URE, while USTEM2 does URE and CVP4. Based on our synthesis of the literature and our research experiences, we *hypothesize* that the CVPs in USTEM2 will develop participants' PSOs more than USTEM1 activities only would[2, 3, 11-13].

3. Analytical Strategy

Outcomes are measured at baseline (M1) and every end-of-semester (M2, end of pre-college summer; M3, end of freshman fall; M4, end of freshman spring; and M5, end of freshman summer). These repeated measures approach allows us to compare and evaluate the efficacy of USTEM2 over USTEM1, characterize trends of outcomes across semesters parametrically (e.g., linear, quadratic), and assess and evaluate USTEM as a STEM-enrichment program methodically and statistically. Once data collection for Cohort3 is completed in July 2024, we will perform a set of *traditional* and *bootstrap* inferential analyses using SAS 9.4 (e.g., PROC GLM, PROC MIXED) and SPSS 29 Premium Version (Generalized Linear Models). In consideration of the *level of measurement*, the *empirical distribution* of outcomes, and our objectives, the analytical techniques we will use are in the form of *analysis of variance*, *generalized linear models* using *normal* (for scores) and *logistic* (for binary outcomes, e.g., graduated or not) link functions, *path analysis*, and *longitudinal analysis*.

<u>In this report, we present preliminary results</u> generated from five completed measurement occasions (M1-M5) for Cohort 1 (at M1: USTEM1, n=22; USTEM2, n=19) and Cohort 2 (at M1: USTEM1, n=12; USTEM2, n=17) vis-à-vis five calculated PSO indicators, namely: 1) academic self-efficacy in STEM *(ASESTEM; an average of 3 items)*, 2) self-efficacy in performing STEM tasks (*STEMTaskSE; average of 4 items*), 3) sense of belonging in STEM (*STEMSB; average of 18 items*), 4) STEM self-identity (*STEMSI; average of 4 items*), and 5) sentiments about staying in a STEM major (*STEMstay; average of 2 items*). Each of the five PSO indicators comprises 7-

point Likert-scaled items averaged and deployed as an online survey using Qualtrics. These items were adopted from the extant literature on STEM education.

4. Results and Discussion

The effects of the cohort (Cohort 1 vs. Cohort 2) and comparison group (USTEM1 vs. USTEM2) were evaluated across five measurements. The results from our analyses are presented in Tables 1A and 1B. No statistically detectable cohort and group effects exist on the five calculated PSO indicators. In other words, there are no significant differences between Cohort 1 and Cohort 2 and between USTEM1 and UTSEM2 with respect to ASESTEM, STEMTaskSE, STEMSB, STEMSI, and STEMstay.

Upon analysis of the data, it was surprising to find no significant differences between USTEM1 and USTEM2, even though USTEM2 participants were exposed to various CVP activities with different social dynamics. This unexpected result requires further investigation to understand the underlying factors contributing to this observation. Although no statistical significance was observed between USTEM1 and USTEM2, a careful look at Table 2 shows that USTEM2 means are consistently higher than USTEM1 means, with large differences pertaining to STEMstay, ASESTEM, and STEMTaskSE. Indeed, adding Cohort3 data will give definiteness to these differences' statistical and substantive significance or lack of significance.

Table 1A and 1B results indicate that measurement occasion (M) significantly impacts all five PSO indicators at either α=.05, .01, or .001 type-I error rates. To better understand the nature and structure of this impact, we conducted a series of *single-degree-of-freedom contrasts* in the form of M2-M1, M3-M1, M4-M1, and M5-M1 [9]. These contrasts estimate change (increase or decrease) in the PSO indicators at the end of each major USTEM activity relative to baseline (M1). This set of tests indicated that there were significant differences in ASESTEM (est. = -.49; $p<.001$) and STEMstay (est. = -.53; $p<.01$) for M3-M1, in STEMSB (est. = .46; $p<.001$) and STEMTaskSE (est. = .23; $p<.05$) for M2-M1, and in STEMSB (est. = .46; $p<.001$) for M5-M1 (Table 3A and 3B).

To further clarify these patterns of differences, we performed tests for polynomial trends on M1-M5. Although there were five measurement occasions, our dataset could only afford to test for *linear* and *quadratic* trends owing to the small sample size and proliferation of missing values at M4 and M5. Attrition among TAMIU USTEM participants was mainly due to personal and family problems, loss of interest in STEM, or failure to meet attendance requirements.

Trend analyses (Table 1A, 1B, 3A, and 3B) for STEMTaskSE, STEMSB, and STEMSI revealed no detectable parametric trends. STEMSB (est. = .66; $p<.05$) exemplified a positive *linear* trend across M1-M5, while ASESTEM (est. = .88; $p<.05$) and STEMstay (est. = 1.22; $p<.05$) exemplified *quadratic* trends whereby dips occurred during the freshman fall semester (M3) and steadily experience gains come spring semester (Table 1A, 1B, and 2). No clear trends were found for STEMTaskSE and STEMSI.

Table1A: GRBD Analysis of Variance for Five PSO Indicators

	ASESTEM					STEMTaskSE					STEMSB				
Source	**DF**	**SS**	**MS**	**Fc**	**Pr > F**	**DF**	**SS**	**MS**	**Fc**	**Pr > F**	**DF**	**SS**	**MS**	**Fc**	**Pr > F**
Cohort (C; 2 categories)	1	0.69	0.69	0.27	0.607	1	0.30	0.30	0.12	0.728	1	0.21	0.21	0.07	0.798
Group (G; 2 categories)	1	0.13	0.13	0.05	0.826	1	0.17	0.17	0.07	0.794	1	0.01	0.01	0.00	0.958
C x G	1	0.79	0.79	0.31	0.581	1	4.64	4.64	1.92	0.171	1	0.56	0.56	0.18	0.676
Error (a)	68	175.30	2.58			68	164.81	2.42			68	217.14	3.19		
Measurement (M)	4	12.34	3.08	5.86	0.000 ***	4	4.99	1.25	3.04	0.019 *	4	8.69	2.17	6.61	0.000 ***
M2-M1	1	0.32	0.32	0.61	0.435	1	1.61	1.61	3.93	0.049	1	6.35	6.35	19.33	0.000 ***
M3-M1	1	7.06	7.06	13.42	0.000 ***	1	0.74	0.74	1.79	0.182	1	0.93	0.93	2.82	0.095
M4-M1	1	1.74	1.74	3.31	0.070	1	0.01	0.01	0.01	0.904	1	0.91	0.91	2.78	0.097
M5-M1	1	0.36	0.36	0.69	0.406	1	0.45	0.45	1.10	0.296	1	5.00	5.00	15.20	0.000 ***
Linear Trend of M	1	1.72	1.72	3.28	0.072	1	0.02	0.02	0.05	0.832	1	1.99	1.99	6.06	0.015 *
Quadratic Trend of M	1	2.83	2.83	5.38	0.021 *	1	0.44	0.44	1.08	0.301	1	0.02	0.02	0.05	0.816
C x M	4	0.66	0.16	0.31	0.870	4	2.46	0.61	1.50	0.205	4	0.96	0.24	0.73	0.573
G x M	4	4.95	1.24	2.35	0.055	4	1.90	0.48	1.16	0.330	4	1.17	0.29	0.89	0.470
C x G x M	4	3.45	0.86	1.64	0.166	4	2.96	0.74	1.80	0.130	4	2.29	0.57	1.74	0.142
Error (b)	206	108.38	0.53			206	84.60	0.41			206	67.72	0.33		

Table1B: GRBD Analysis of Variance for Five PSO Indicators

	STEMSI						STEMstay					
Source	**DF**	**SS**	**MS**	**Fc**	**Pr > F**		**DF**	**SS**	**MS**	**Fc**	**Pr > F**	
Cohort (C; 2 categories)	1	0.09	0.09	0.02	0.888		1	0.27	0.27	0.04	0.836	
Group (G; 2 categories)	1	0.01	0.01	0.00	0.969		1	3.42	3.42	0.55	0.462	
C x G	1	2.10	2.10	0.45	0.506		1	7.45	7.45	1.19	0.279	
Error (a)	68	320.28	4.71				68	426.07	6.27			
Measurement (M)	4	6.54	1.64	3.49	0.009	**	4	20.97	5.24	4.75	0.001	**
M2-M1	1	3.25	3.25	6.92	0.009	**	1	1.81	1.81	1.64	0.202	
M3-M1	1	0.11	0.11	0.24	0.628		1	8.43	8.43	7.63	0.006	**
M4-M1	1	0.30	0.30	0.64	0.426		1	1.80	1.80	1.63	0.204	
M5-M1	1	0.06	0.06	0.12	0.729		1	0.11	0.11	0.10	0.752	
Linear Trend of M	1	0.52	0.52	1.10	0.295		1	0.63	0.63	0.57	0.452	
Quadratic Trend of M	1	0.00	0.00	0.00	0.999		1	5.46	5.46	4.95	0.027	*
C x M	4	1.55	0.39	0.83	0.509		4	3.27	0.82	0.74	0.566	
G x M	4	1.98	0.50	1.06	0.379		4	1.50	0.38	0.34	0.851	
C x G x M	4	2.19	0.55	1.17	0.325		4	10.48	2.62	2.37	0.054	
Error (b)	206	96.64	0.47				206	227.61	1.10			

*, **, *** significant at the .05, .01, and .001 type-I error rates, respectively; M1 is baseline

Table 2: Means of PSO Indicators for Cohort, Group, and Measurement Categories.

Category	ASESTEM		STEMTaskSE		STEMSB		STEMSI		STEMstay	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Cohort1	5.95	0.06	5.94	0.05	5.72	0.05	5.48	0.06	5.84	0.09
Cohort2	5.84	0.08	5.86	0.07	5.78	0.07	5.52	0.08	5.76	0.12
USTEM1	5.87	0.07	5.87	0.06	5.74	0.06	5.49	0.07	5.67	0.11
USTEM2	5.92	0.07	5.92	0.06	5.76	0.06	5.50	0.07	5.93	0.11
Measurement 1	6.05	0.09	5.89	0.13	5.49	0.07	5.46	0.09	5.85	0.08
Measurement 2	6.15	0.10	6.14	0.14	5.95	0.08	5.78	0.09	6.08	0.08
Measurement 3	5.56	0.10	5.36	0.14	5.67	0.08	5.39	0.09	5.69	0.09
Measurement 4	5.79	0.11	5.63	0.16	5.68	0.09	5.35	0.11	5.87	0.10
Measurement 5	5.92	0.12	5.96	0.18	5.96	0.10	5.51	0.12	5.99	0.11

Mean = least squares mean; SEM = standard error of the least squares mean.

Table 3A: Contrasts and Trends for Measurements on PSO Indicators

Contrast; Trend	ASESTEM			STEMTaskSE			STEMSB		
	Est	SE	Pr > |t|	Est	SE	Pr > |t|	Est	SE	Pr > |t|
M2 - M1	0.10	0.13	0.4351	0.23	0.12	0.0487*	0.46	0.10	0.0001***
M3 - M1	-0.49	0.13	0.0003***	-0.16	0.12	0.1822	0.18	0.11	0.0946
M4 - M1	-0.26	0.14	0.0702	0.02	0.13	0.9037	0.19	0.11	0.0969
M5 - M1	-0.13	0.15	0.4064	0.14	0.13	0.2957	0.46	0.12	0.0001***
linear	-0.61	0.34	0.0718	0.06	0.30	0.8318	0.66	0.27	0.0147*
quadratic	0.88	0.38	0.0213*	0.35	0.33	0.3006	-0.07	0.30	0.8163

*, **, *** significant at the .05, .01, and .001 type-I error rates, respectively;
Est = estimated coefficient; M1 is baseline.

Table 3B: Contrasts and Trends for Measurements on PSO Indicators

Contrast; Trend	STEMSI			STEMstay		
	Est	SE	Pr > |t|	Est	SE	Pr > |t|
M2 - M1	0.33	0.12	0.0091**	0.24	0.19	0.2022
M3 - M1	-0.06	0.13	0.6282	-0.53	0.19	0.0063**
M4 - M1	-0.11	0.13	0.4256	-0.26	0.21	0.2036
M5 - M1	0.05	0.14	0.7290	0.07	0.22	0.7523
linear	-0.34	0.32	0.2948	-0.37	0.49	0.4523
quadratic	0.00	0.36	0.9985	1.22	0.55	0.0272*

*, **, *** significant at the .05, .01, and .001 type-I error rates, respectively;
Est = estimated coefficient; M1 is baseline.

It is worth noting that the trends observed concerning these two indicators STEMTaskSE and STEMSI, may have been *cubic*. Unfortunately, it was impossible to estimate this form accurately due to the high number of missing values resulting from participant attrition at M4 and M5. It is important to note that ASESTEM and STEMTaskSE are self-efficacy indicators, but they measure different aspects of efficacy and exhibit distinct trends, as shown in Table 3A. STEMTaskSE evaluates efficacy related to practical tasks and hands-on skills. At the same time, ASESTEM is concerned with conceptual and theoretical aspects such as critical or analytical thinking skills, such as processing, comprehending, and synthesizing STEM course content.

Based on the data collected thus far, it is evident that the USTEM program has positively impacted the participants' sense of belonging regardless of group assignment (USTEM1 or USTEM2). This improvement occurred gradually across the five measurement occasions, with the most significant gains observed during the summer camps. The laid-back and inclusive environment of the camps provided the ideal setting for the participants to connect, socialize, and forge new relationships. The participants could engage in various enjoyable learning activities, form new friendships, strengthen existing ones, and spend quality time with their peers. All these experiences played an instrumental role in helping the participants develop a deep-seated sense of belonging and connectedness within the USTEM community. Preliminary results indicate that USTEM participants tend to struggle with academic self-efficacy and their intention to remain in STEM during their freshman fall. However, this tendency improves steadily after this period. Their initial exposure to college-level STEM courses, college life, and expectations may have led to doubts about their abilities. However, they appear to have recovered from these doubts by the end of their freshman spring semester.

5. Conclusion

Based on our initial analysis of data from Cohort 1 and 2, we have found that the measurement occasion has a noticeable impact on PSOs. However, we have not observed significant differences between cohorts or comparison groups (no apparent difference between USTEM1 and USTEM2). Our findings suggest that USTEM participants experience an improved sense of belonging during pre-college and freshman summer camps, which are more relaxed times and may have provided participants with opportunities to bond with old and make new friends. On the other hand, we have observed a decline in academic self-efficacy and intention to stay in STEM during the freshman fall semester. This could be attributed to the combined effect of the participants' first-time exposure to college-level STEM courses, a new social environment, and the demands of college life. It is worth noting that data collection for Cohort 3 is still ongoing, and we will update our results once these data are included in our analyses. That said, our results are preliminary and definitive findings from this multi-year panel-type longitudinal experiment will only be available once all measurements (M1-M5) for all three cohorts (blocks) are made, validated, and analyzed.

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