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STEM Academic & Career Identity Formation Among Middle School Students

Heather A. Williquette & David H. Khaliqi

University of Colorado, Colorado Springs

Abstract: *The study examined the impact of STEM education workshops on changes in student's self-reported academic and professional identity.*

Keywords: *STEM; Education Camps; Middle School*

Purpose of the Study

The purpose of this study was to examine the impact of hands-on STEM education camps on middle school student's desire to take STEM-related classes in high school and college (i.e. academic identity) compared to their desire to pursue a STEM career (i.e. professional identity). This examination was conducted using data collected over 3 years of STEM summer and academic year programs at a four-year comprehensive university in the western United States through that institution's STEM education center.

This study addresses the following research question: Are hands-on STEM programs equally effective at developing a STEM academic identity as a STEM career identity or is one developed more strongly than the other after participation?

Review of the Literature

Much work has been done around the notion of preparing young students to consider STEM careers as early as possible (Augustine et al., 2007). The hypothesis is that the earlier students begin thinking and planning their career trajectories in STEM, the more success they will have in achieving these ambitious goals (Wang & Degol, 2013). Given this hypothesis, STEM outreach programs have proliferated across the country in an effort to attract more students to STEM careers.

Several studies have observed that relevance and student motivation are directly correlated in that students' motivation improved when they pictured themselves succeeding in something they deemed valuable or relevant to their lives(Hulleman & Harackiewicz, 2009). Importantly this relationship held true among students expressing a low degree of STEM motivation prior to treatment.

Other studies have examined the role that STEM academic preparation and motivation may play in attracting students into the STEM pipeline. Wang & Degol (2013) observed that a student's intention to major in a STEM field is a product of motivational attributes and learning related to math achievement and exposure to math and science courses. Importantly, these factors were most important in attracting students to STEM majors and generally occurred in high school

Correspondence concerning this article should be addressed to David Khaliqi, E-mail: dkhaliqi@uccs.edu

(Maltese & Tai, 2011; Tai, Liu, Maltese, & Fan, 2006). Hidi & Renninger (2006) observed that it is important to first engender a strong academic identity then expose students to possible careers stemming from these academic areas.

Clearly, there is a need to understand how STEM course taking and academic performance relate to the pursuit of a STEM major and how educators can leverage this sequence in an efficient and effective manner to support the development of more STEM motivated students in younger grades?

Purpose of the Study

The purpose of this study was to assess the effects of this summer school program on the learning and retention of mathematics knowledge of the participants. Although each student in the summer program participated in mathematics, literacy, and arts enrichment classes, the focus of this study was to specifically look at the mathematics learning.

Methods

The sample (n = 74) was derived from several pre/post program surveys used by a STEM education center at a western 4-year university among student who were involved in STEM-motivational camps run between 2010-2013. Self-selection bias was considered and as such, only students reporting a low interest in STEM on pre-surveys were included in the sample.

These programs were designed to improve student motivation to pursue a STEM career using hands-on activities and labs. Surveys examined change in attitude toward pursuing a STEM career using four Likert-scale items. Additionally four items measured the student's desire to take more STEM courses in high school and four additional items for college. Paired-sample t-tests and Cohen's d effect sizes were computed to test statistical significance and strength of relationship statistics for comparison purposes between the two constructs.

Data were screened for missing data, outliers, and assumptions of normality. Missing data was addressed using pair-wise deletion to maintain adequate statistical power. No outliers and violations of normality were observed.

Instruments and Procedure

A program-designed survey instrument was administered to students using a non-experimental pre-test/post-test design. Pre-surveys were administered at the beginning of each camp and a post-survey was administered to students at the end of each camp. Surveys consisted of twelve questions that examined change in attitude toward pursuing a STEM career (α = .90); desire to take more STEM courses in high school (α = .92); and the desire to take more STEM courses in college (α = .85). STEM interest was measured with a 6-point Likert scale ranging from 1 (Definitely False) to 6 (Definitely True). As an alternative response, participants could choose to opt out of questions by selecting 7 (I prefer not to answer). Self-selection bias was addressed by filtering and retaining students who answered 1,2, or 3 on the pre-test for any measure.

We ran paired-samples t-tests and computed Cohen's d effect sizes to test statistical significance and strength of relationship statistics for low STEM-motivated students between pre- and post-surveys. As mentioned above, the sample was comprised of low STEM-motivated students (students who selected a 1, 2, or 3 in the pre-survey) to minimize self-selection bias.

Results

Consistent with our hypothesis, significant differences were found between means for STEM Career pre- and post-surveys (see Table 1). Specifically, low STEM-motivated students had significantly higher beliefs that a STEM career was possible for them, higher confidence in succeeding in a STEM career, an improved desire to pursue a STEM career, and higher confidence in knowing what they wanted to do for a STEM career.

Table 1. *Changes in attitude toward a STEM career*

Career (1,2,3 Pretest)	M	SD	N	M_2-M_1	t	d
The idea of a career in STEM seems possible (PRE)	2.33	0.84	30	1.87*	7.14	1.85
The idea of a career in STEM seems possible (POST)	4.20	1.16				
I am confident that I can succeed in a STEM career (PRE)	2.23	0.91	26	1.73*	5.55	1.44
I am confident that I can succeed in a STEM career (POST)	3.96	1.43				
I want a career in STEM (PRE)	2.10	0.94	39	1.44*	6.83	1.14
I want a career in STEM (POST)	3.54	1.52				
I know what I want to do in a STEM career (PRE)	2.35	0.83	54	1.34*	6.26	1.17
I know what I want to do in a STEM career (POST)	3.69	1.39				

Note: *$p < .001$

Significant differences were also found between means for STEM College pre- and post-surveys (see Table 2). Specifically, low STEM-motivated students had significantly higher confidence in handling STEM courses in college, higher desire to study STEM in college, and higher desire to major in a STEM field in college. Interestingly, students' anxiety about taking STEM courses in college also increased significantly.

Table 2. *Changes in attitude toward taking STEM courses in college*

College (1,2,3 Pretest)	M	SD	N	M_2-M_1	t	d
I am confident that I can handle STEM courses in college (PRE)	2.45	0.86	22	2.23*	7.23	2.03
I am confident that I can handle STEM courses in college (POST)	4.68	1.29				
I would like to study STEM in college (PRE)	2.33	0.73	46	1.32*	8.20	1.39
I would like to study STEM in college (POST)	3.65	1.14				
I plan to major in a STEM field in college (PRE)	2.55	0.80	58	1.11*	6.64	1.16
I plan to major in a STEM field in college (POST)	3.66	1.09				
I am anxious about taking STEM courses in college (PRE)	2.34	0.83	70	0.73*	4.03	0.60

I am anxious about taking STEM courses in college (POST)	3.07	1.50

Note. * $p < .001$

Large significant differences were found between means for STEM High School pre- and post-surveys (see Table 3). Specifically, low STEM-motivated students had significantly higher desire to learn more about STEM in high school, higher interest in taking STEM courses in high school, higher confidence in doing well in a STEM class in high school, and higher desire to learn more about STEM than what is required in high school.

Table 3. *Changes in attitude toward taking STEM courses in high school*

High School (1,2,3 Pretest)	M	SD	N	M_2-M_1	t	d
I want to learn more about STEM in HS (PRE)	2.57	0.67	42	1.72*	9.30	1.88
I want to learn more about STEM in HS (POST)	4.29	1.11				
I am interested to take STEM courses in HS (PRE)	2.56	0.74	41	1.71*	8.48	1.91
I am interested to take STEM courses in HS (POST)	4.27	1.03				
I know I will do well in a STEM class in HS (PRE)	2.48	0.80	33	1.91*	7.18	2.00
I know I will do well in a STEM class in HS (POST)	4.39	1.09				
I plan to learn more about STEM than what is required in HS (PRE)	2.43	0.72	54	1.63*	10.09	1.97
I plan to learn more about STEM than what is required in HS (POST)	4.06	0.92				

Note: *$p < .001$

Composite scores were calculated across the entire sample (to include pretest responses of 4,5, and 6) to observe the overall differences in STEM interest between High School, College, and Career constructs among high and low motivation students (see Table 4).

Table 4. *Composite scores across total sample*

COMPOSITES (TOTAL)	M	SD	N	M_2-M_1	t	p	d
HS: BEFORE	4.72	1.17	236	0.50	9.08	< .001	0.50
HS: AFTER	5.22	0.81					
COLLEGE: BEFORE	4.53	1.04	236	0.37	7.11	< .001	0.38
COLLEGE: AFTER	4.90	0.91					
CAREER: BEFORE	4.63	1.13	236	0.46	8.63	< .001	0.45
CAREER: AFTER	5.09	0.89					

We found the largest mean difference between the high school pre and post-surveys. The second highest mean difference was in Career. Although the lowest mean difference was between College pre and post-survey questions, the findings were still statistically significant.

Discussion and Conclusions

The current study explored the relationship between STEM professional identity and STEM academic identity. Numerous studies have shown that incorporating relevance in hands-on activities significantly increases STEM motivation, especially in students who are not highly motivated to begin with (Hulleman & Harackiewicz, 2009). We replicated this finding by observing pre- and post-survey scores from low STEM-motivated students who enrolled in hands-on STEM programs designed to increase their interest in STEM.

Although desire to pursue both a STEM major in college and a STEM career in the future both had significant increases from pre- to post-surveys, the strongest effect sizes and largest mean differences were found in responses regarding interest in taking STEM classes in high school. This finding was not consistent with our hypothesis, since the workshop curriculum focused more on the development of a career or professional identity than the development of an academic identity.

These findings seem to indicate the possibility that STEM academic identity development is worthy of greater investment by STEM education providers rather than the heavy emphasis on STEM career identity that is the norm in such programs. Given the large number of STEM outreach efforts across the U.S., it is important to understand the specific areas of change that occurs in students after their participation in such events. Some observers have noted that encouraging students to think about a STEM major and STEM career need to be the focal outcome of such programs. However, our research indicates that while encouraging students to think forward toward college may be beneficial, for students who hold a low motivation in STEM, speaking to them about STEM opportunities at the next grade level may be a key component that is generally missing from STEM workshop dialogues

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