The STEAM Journal

Volume 5 | Issue 1 Article 7

February 2023

Students Arts Participation Increases STEM Motivation via Self-Efficacy

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STEAM is a bi-annual journal published by the Claremont Colleges Library | ISSN 2327-2074 | http://scholarship.claremont.edu/steam

Students Arts Participation Increases STEM Motivation via Self-Efficacy

Abstract

This work found that there exists a correlation between student motivation in science, technology, engineering and mathematics (STEM) and student participation in the arts during high school with self-efficacy being a mediator. STEM is an important component of student success from a broad, national, perspective, as well as from a domain-specific point of view. The results of this work may provide aid to teachers, parents, administrators, and even students seeking to find ways to increase student motivation and performance in the STEM subjects. Additionally, this work may be of interest to advocates of the arts. This quantitative correlational study was done using Hayes' PROCESS via data resampling via bootstrapping 5,000 times with a 95% confidence interval at a statistical significance at the $a = 0.05$ level. The results of this study found an indirect effect of the predictor variable of arts participation on the dependent variable of STEM motivation of $b = 0.003$, 95% CI [0.000, 0.009], and a direct effect of $b = 0.003$ $p < 0.05$. Additionally, this study found the predictor variable of arts participation was correlated to the mediator variable of self-efficacy. $b = 0.006$ at $p < 0.05$.

Keywords

STEM, STEAM, motivation, arts, arts participation, Hayes' PROCESS, science, technology, engineering mathematics, mediation, correlation, mediator, self-efficacy

Cover Page Footnote

This author would like to acknowledge Dr. Bob Bulik, Dr. Armando Paladino and Dr. Amy Dietzman

Arts Participation by Students Increases STEM Motivation via Self-Efficacy Mediation

Stephen Dahlem (Grand Canyon University)

Introduction

The domain of the arts includes multiple elements. Some of these elements relate to dance, visual, music, and theater centered activities. Lekue (2015) found that when students participate in the domain of the arts during high school, that participation results in their gaining of a sense of performance accomplishment. This performance accomplishment instills in those involved a sense of success which fosters motivational increases in other domains. The most notable of those other domains, from the perspective of students, administrators, educators, leaders, and parents is that of the STEM disciplines. The goal of this study was to determine whether there existed a correlation between student motivation in science, technology, engineering, and mathematics (STEM) and student participation in the arts during high school with self-efficacy being a potential mediator.

Previous research has revealed a correlation between success in STEM subjects, and student motivation to participate in those subjects (McDonald, 2016). The literature supports this correlation, arguing that success in the STEM disciplines is not the result of natural ability or talent, but rather the result of motivation to participate in those fields (Cogdill, 2015). Furthermore, other authors (Niranjan, Jun & Jenner, 2015; Svoboda, Rozek, Hyde, Harackiewicz & Destin, 2016) have found that domain-specific motivation, such as STEM motivation, can be linked to a student having a history of success in multiple domains, academic, and otherwise.

What is more important in STEM education is that students who study STEM are not only able to satisfy state and federal base level testing requirements in basic science, mathematics, and technology, but rather that students become proficient at the utilization of the core principles taught in STEM subjects (Kennedy et. al, 2014; McDonald, 2016). The workforce of the 21st century will be competitive, and the students and nations most proficient in STEM subjects will have a distinct advantage (Atkinson & Mayo, 2010). STEM subjects are typically hierarchical, meaning that mastery of one subject is required to move on to the next. This has implications. For students to be able to pursue STEM-related careers after college, they need to have a college degree which often first requires the completion of a hierarchical series of courses that begins with elective high school-level STEM courses (Kennedy et. al, 2014).

Despite this, many high school and undergraduate students in the United States are not motivated to enroll in more than the few, mandatory, STEM courses required to complete their degrees (Shaffer, 2019). Recent research into STEAM, (science, technology, engineering, arts, and mathematics) has shown that maintaining student motivation in STEM is more challenging than in STEAM (Conradty & Bogner, 2019). This is because students who participate in the arts are motivated differently than those participating solely in STEM (Acosta, 2015). This sentiment has been echoed by other authors who have identified that maintaining student motivation, in subjects such as STEM, is one of the greatest challenges facing educators (McDonald, 2016; Theobald, 2006).

Theory

Motivation is described in the literature as being the reasoning behind a person's goals, willingness, or actions (Bandura & Schunk, 1981). Schunk (2004) described motivation as being an

internal condition of a student which serves to focus their behavior and instigate their desire to participate in the learning process. Students who possess high levels of academic motivation tend to achieve higher levels of both academic success and overall educational attainment (McDonald, 2016; Niranjan, Jun & Jenner, 2015). Anderson and Ward (2014) have shown quantitatively that students who have a history of success academically can draw motivation internally from their previous academic successes, especially when faced with a new, unfamiliar, or challenging subject or domain. Likewise, Anderson et. al (2014), showed quantitatively that students are less motivated to participate in situations or domains where they feel unlikely to be successful.

Self-efficacy, or the internal belief possessed by an individual that they will be able to complete a task or undertaking, is described in the literature as being a primary mediating factor of student success (Bandura, 1977; Honicke & Broadbent, 2016). STEM motivation may be described as the willingness of a student to voluntarily take STEM courses or engage in STEM-field related endeavors (Kennedy & Odell, 2014; McDonald, 2016). The relationship between self-efficacy generated through a student's participation in the arts during high school and their subsequent motivation towards STEM subjects has not been studied quantitatively. Wang and Degol (2017) have expressed a need for research to examine how motivating factors that arise from participation in academic domains other than STEM, such as the arts, contribute to student STEM motivation levels. Butz and Usher (2015) also expressed a similar need by asking future researchers, the exploratory question, "how well does self-efficacy generated in one domain, such as the arts, transfer to another domain, such as found in STEM?"

Participation in the arts creates an environmental and psychological situation that promotes a sense of achievement and success amongst those who participate in them (Jones, Chittum, Akalin, Schram, Fink, Schnittka & Brandt, 2015). Bandura (1977) found that performance-accomplishment, such as is obtained through participation in the arts, is one of the primary contributors towards self-efficacy. It is not known whether this increase in self-efficacy is STEM-specific. However, research has shown that the self-efficacy component of motivation can produce positive effects in more than the domain in which it was initially generated (Butz & Usher, 2015).

Purpose Statement and Methodology

The purpose of this quantitative, correlational regression study was to investigate self-efficacy as a potential mediator in the relationship between the amount of time students who are beginning college spent during high school participating in the arts and their current motivation levels towards STEM. Participants first provided informed consent to participate in the study, then were presented with a number of items delivered electronically. These items first screened demographics, then screened for arts participation levels based on the Survey for Public Participation in the Arts (SPPA). Finally, students were administered the Science Motivation Questionnaire (SMQ).

The SMQ uses a Likert scale method for gauging participant responses and is specifically tailored towards STEM subjects. It is designed to gauge both overall STEM motivation as well as self-efficacy (Glynn et. al, 2011). In this study, the amount of time a student spent participating in the arts during high school was the predictor variable, STEM motivation was the criterion variable, and self-efficacy was the mediator variable (Frazier, Tix & Barron, 2004).

Research Questions and their Associated Hypotheses

This study investigated the general hypothesis that there is a positive correlation between participation in the arts during high school and STEM motivation levels when students begin college at the undergraduate level via three research questions. The results of this study supported this general hypothesis and also found that this relationship was mediated by self-efficacy. The research questions and their associated hypothesis are as follows:

RQ1: To what extent is there a predictive relationship between the amount of time a student spends participating in the arts during high school and their STEM motivation when they begin community college?

> **H_{01}:** There is no significant predictive correlation between the amount of time a student spends participating in the arts during high school and their STEM motivation when they begin community college.
>
> **H_{1a}:** There is a significant predictive correlation between the amount of time a student spends participating in the arts during high school and their STEM motivation when they begin community college.

RQ2: To what extent is there a predictive relationship between the amount of time a student spends participating in the arts during high school and their self-efficacy when they begin community college?

> **H_{02}:** There is no significant predictive correlation between the amount of time a student spends participating in the arts during high school and their self-efficacy when they begin community college.
>
> **H_{2a}:** There is a significant predictive correlation between the amount of time a student spends participating in the arts during high school and their self-efficacy when they begin community college.

RQ3: To what extent, if any, is there a mediation effect by self-efficacy upon the predictive relationship between the amount of time a student spends participating in the arts during high school and STEM motivation when students begin community college?

> **H_{03}:** Self-efficacy does not significantly mediate the predictive relationship between the amount of time a student spends participating in the arts during high school and their STEM motivation when they begin community college.
>
> **H_{3a}:** Self-efficacy does significantly mediate the predictive relationship between the amount of time a student spends participating in the arts during high school and their STEM motivation when they begin community college.

Data Cleaning

Once all of the responses had been collected from SurveyMonkey, they were then cleaned and prepared for analysis using Hayes' PROCESS. Of the *N*=105 respondents who completed the entire survey on SurveyMonkey, *n*=37 either did not meet the requirements for the survey, failed to provide informed consent, provided the same response on all of the available responses, or provided responses which directly contradicted each other. These *n*=37 respondents were removed from the study which resulted in *N*=68 respondents which met the criteria for this study and were included.

Power Analysis

Based upon the original *a priori* G-Power sample size calculations (Appendix E) the sample size used in the data analysis was capable of producing a power of 0.804, slightly above the desired power of 0.800 for this study. To confirm this, G-Power was used to perform a *post hoc* power analysis on the actual sample size, *N=68,* used in the data analysis, and confirmed that the power (1-β err probability) was indeed 0.804.

Descriptive Statistics

Descriptive statistics on the data was tabulated. The SMQ consists of five constructs which, when averaged together, are considered to provide a statistical representation of the level of motivation a student experiences towards STEM. A higher average score on the SMQ represents a higher student motivation level towards STEM, likewise, a lower average score on the SMQ represents a lower student motivation level towards STEM. To calculate the average of each construct, each of the five Likert responses per respondent was added together, then that total was divided by 5, providing the average score on that construct. To calculate the average SMQ score overall, all 25 items were added together, and that total was divided by 25.

Table 1.

Group Statistics for Variables by Gender

Variable	Gender	N	Mean	St. Dev.	Std. Error
Predictor	Male	21	28.95	30.012	6.549
(Arts Participation)	Female	47	40.30	38.724	5.648
Criterion	Male	21	2.514	0.735	0.160
(SMQ Score)	Female	47	2.485	0.720	0.105
Mediator	Male	21	2.571	0.947	0.207
(Self-Efficacy)	Female	47	2.396	0.867	0.127

Data Analysis

The constructs on the SMQ were scored using a Likert scale which measured the degree to which a participant agreed with the item component of a construct. Higher scores on an item were indicative that a participant agreed more with the item, and lower scores indicated that a participant disagreed with an item. The Likert scale which was used to measure STEM motivation via the 25 items of the SMQ ranged from zero to four, which corresponded to language consisting of 'never to all the time.' Meaning, if a participant agreed more with the item in a construct, they answered with a higher score

for that item. Low average scores in a construct represent components of motivation in which the sample has expressed lower levels of agreement.

Before data was analyzed using Hayes' PROCESS, it was tested to determine whether the standard assumptions of linear regression were met. This study found that all the variables exhibited a normal distribution and a linear relationship existed between the variables. Furthermore, this research ensured that the variables were measured with reliability and exhibited homoscedasticity (Osborne & Waters, 2002). This research used visual inspection of P-P plots, Q-Q residual to test the normality of the mean data for the two primary variables and to test for linearity.

Results

Table 2.

Mean, Standard Deviation, Skewness, Kurtosis and Coefficient Alpha Estimates of Reliabilities Between Study Variables (N=68)

Variable	***Mean***		***SD***	***Skewness***		***Kurrtosis***	
	Statistic	*Error*		Γ	SE	κ	SE
	2.494	0.087	0.719	0.071	0.291	-0.505	0.574
SMQ Score All Subsections							
Intrinsic Motivation Subsection Average	2.500	0.107	0.884	-0.103	0.291	-0.544	0.574
Career Motivation Subsection Averages	2.509	0.103	0.849	0.282	0.291	-0.753	0.574
Self-Determination	2.397	0.094	0.775	0.121	0.291	-0.600	0.574

Subsection Average							
Self-Efficacy Subsection Averages	2.450	0.108	0.889	-0.372	0.291	0.127	0.574
Grade Motivation Subsection Averages	2.577	0.098	0.098	-0.069	0.291	-0.362	0.574

The mean SMQ score was 2.494 *(SD=0.719)*. Responses to the SMQ overall were normally distributed, with skewness of 0.071 *(SE=0.291)* and kurtosis of -0.505 *(SE=0.574).* The mean self-efficacy score was 2.450 *(SD=0.889)*. Self-efficacy scores were also normally distributed, with skewness of -0.372 *(SE = 0.291)* and kurtosis of -0.127 *(SE = 0.574).*

Table 3:

The Science Motivation Questionnaire Results

Construct	**Sample** (*N* = 68)	**Male** (*n*=21)	**Female** (*n*=47)	**Glynn et. al** (2011, *n*=313)
Overall SMQ Score				
M	2.4941	2.514	2.485	2.540
Sd	0.719	0.735	0.720	0.709
Intrinsic Motivation				
M	2.500	2.524	2.490	2.282
Sd	0.884	0.843	0.911	0.738
Career Motivation				
M	2.509	2.467	2.528	2.226
Sd	0.849	0.882	0.843	0.980

Self-Determination				
M	2.397	2.324	2.430	2.722
Sd	0.775	0.739	0.796	0.622
Self-Efficacy				
M	2.450	2.571	2.396	2.250
Sd	0.889	0.947	0.867	0.668
Grade Motivation				
M	2.577	2.562	2.583	3.222
Sd	0.807	0.841	0.801	0.538

This research used Hayes' PROCESS for mediation (Field, 2013) to conduct one procedure in SPSS in which the dependent variable, STEM motivation was analyzed. Using the Hayes' PROCESS custom dialog box in SPSS, this research tested the following relationships simultaneously: the independent variable (arts participation) and the mediator (self-efficacy), the direct effect of arts participation on the dependent variable (STEM motivation), and the indirect effect of arts participation on STEM motivation through self-efficacy. This was done via a process of data resampling with replacement via bootstrapping 5,000 times, the indirect effect of self-efficacy was calculated with a 95% confidence interval at a statistical significance at the $a = 0.05$ level. The overall combination of this indirect effect with the direct effect of the predictor on the criterion variable resulted in what Hayes' PROCESS reported as the total effect.

Table 4.

Hayes' PROCESS output for Self-Efficacy and Overall SMQ

```
OUTCOME VARIABLE:

SelfEfic

Model Summary

          R       R-sq        MSE          F        df1        df2          p

       .241       .058       .756      4.079      1.000     66.000       .048

Model

              coeff         se          t          p       LLCI       ULCI

Arts_Par       .006       .003      2.020       .048       .000       .012


OUTCOME VARIABLE:

Avrg_SMQ

Model Summary
```

```
          R        R-sq         MSE           F         df1         df2           p
       .878        .771        .122     109.366       2.000      65.000        .000
Model
              coeff          se           t           p        LLCI        ULCI
Arts_Par       .003        .001       2.454        .017        .001        .005
```

This study hypothesized that there would be a relationship of significance between student participation in the arts during high school and STEM motivation when those students began community college. Based on the PROCESS results which tested for the direct effect of student participation in the arts during high school on their STEM motivation when they begin community college, these results affirmed the notion that there does exist a relationship of significance between arts participation and STEM motivation. This study also hypothesized that there would be a similar significant relationship between student participation in the arts during high school and self-efficacy. Likewise, the PROCESS results affirmed that such a significant relationship existed.

The results of the PROCESS analysis found that the calculated correlation coefficient, or B-value, for the relationship between arts participation and STEM motivation is *B*=0.003 with a confidence interval of LLCI=0.001 and an ULCI=0.005, representing a 95% confidence interval for the correlation coefficient. The R-value of 0.878 indicates that the relationship between arts participation and STEM motivation exhibits a strong linear relationship. Because the value 0.000 does not exist between the LLCI and the ULCI, this correlation coefficient was accepted with a *SE*=0.001, a *t*=2.454 and a *p*=0.017. Because this *p* value is less than 0.05, this correlation coefficient is considered significant. For every hour increase in arts participation by high school students, this study found that the average SMQ scores of participants increased by 0.003 units.

The calculated correlation coefficient, or B-value, for the relationship between arts participation and self-efficacy is *B*=0.006 with a confidence interval of LLCI=0.000 and an ULCI=0.012, representing a 95% confidence interval for the correlation coefficient. Because the value 0.000 does not exist between the LLCI and the ULCI, this correlation coefficient was accepted with a *SE*=0.003, a *t*=2.020 and a *p*=0.048. Because this *p* value is less than 0.05, this correlation coefficient is considered significant. This research found that as student participation in the arts increased by units of one hour, their self-efficacy when they began community college increased by 0.006 units.

Note that the R value for the relationship between Arts Participation and STEM motivation is 0.879 indicating a strong positive linear relationship between the two variables. The smaller R value for the relationship between self-efficacy indicates that a linear relationship does exist, but is not as strong. This sort of result is expected when a variable is a mediator in a relationship.

Table 5:

The Ability of Arts Participation to Predict STEM Motivation and Self-Efficacy

Outcome	*b*	*R*	R^2	*MSE*	*F*	*df1*	*df2*	*p*
STEM Motivation								
(SMQ Overall)	.003	.878	.771	.122	109.366	2.00	65.00	.017
Self-Efficacy	.006	.241	.058	.756	4.079	1.00	66.00	.048

This study, via PROCESS analysis, found that the direct effect of arts participation on STEM motivation was 0.003 with a lower level confidence interval (LLCI) of 0.001 and an upper level confidence interval (ULCI) of 0.005 at a 95% confidence interval. This study also found that the indirect effect of arts participation on STEM motivation was 0.004 with a lower level confidence interval (LLCI) of 0.000 and an upper level confidence interval (ULCI) of 0.009 at a 95% confidence interval. Because 0.000 is not between the LLCI and the ULCI of either of these measurements, this study was able to accept hypothesis 3 with an effect size of 0.004 and reject the null hypothesis which argued that self-efficacy does not significantly mediate the relationship between student participation in the arts during high school and their STEM motivation when they begin community college.

This study found that the direct effect of arts participation on STEM motivation had an effect size, *R*=0.003 with a *SE*=0.001, a t=2.454 at a significance of *p*=0.017. Since *p*<0.05, the effect is significant. Additionally, because 0.000 does not lie between the 95% confidence interval of LLCI=0.001 and the ULCI=0.005, this effect is considered valid.

Table 6:

Direct and Indirect Effects of Arts Participation on STEM Motivation.

Direct effect of Arts Participation on STEM Motivation*:

Effect	*se*	*t*	*p*	*LLCI*	*ULCI*
0.003	0.001	2.454	0.017	0.001	0.005

Indirect effect of Arts Participation on STEM Motivation*:

Mediator	*Effect*	*BootSE*	*BootLLCI*	*BootULCI*
Self-Efficacy	0.004	0.002	0.000	0.009

* Level of confidence for all confidence intervals in output:

95.0000

* Number of bootstrap samples for percentile bootstrap confidence intervals:

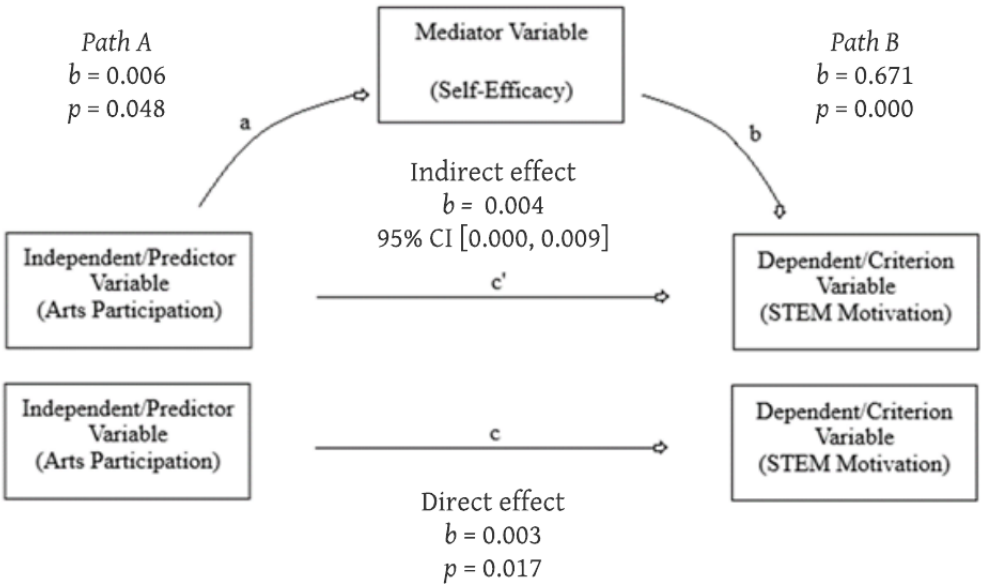
5000

This study found that the indirect effect of arts participation on STEM motivation had an effect size, *R*=0.004. The data was bootstrapped 5000 times and resulted in a Boot*SE*=0.001. Additionally, because 0.000 does not lie between the 95% confidence interval of LLCI=0.000 and the ULCI=0.009, this study found that mediation did occur. Self-efficacy was found to have a significant mediating effect on this relationship which accounted for 25% of the variance between the direct and indirect effects.

Figure 5, path A represents the relationship between student participation in the arts during high school and self-efficacy when a student begins community college. In Figure 5, path C is a representation of the relationship between student participation in the arts during high school and STEM motivation when they begin community college with no mediation by self-efficacy. In Figure , paths C’ and B represent the effect of student participation in the arts during high school on STEM motivation when they begin community college through the mediating effects of self-efficacy.

Figure 1.

Self-Efficacy Mediation of Arts Participation on STEM Motivation Model



Summary of Results

The intent of this research was to first determine the presence, then if present, the extent of the relationship between the predictor, criterion, and mediating study variables. A quantitative correlational methodology was selected because it was the best methodology suited for such a statistical evaluation. To conduct this study, Hayes' PROCESS for mediation was used to predict the effect of student participation in the arts during high school on STEM motivation. By using PROCESS to conduct a model which analyzed the presence and effect size of mediation upon such a relationship, such a mediating effect was found and quantified by this study. Self-efficacy was found to be a mediator of the relationship between arts participation and STEM motivation and was found to strengthen the relationship between these variables.

Discussion

This study provided information about the mediating effect of self-efficacy on the relationship between student participation in the arts during high school and STEM motivation when they begin community college. This study found that, in general, students who have completed high school and are considering attending community college have moderate levels of STEM motivation and self-efficacy. Furthermore, there is a notable difference in the self-efficacy levels between male and female students considering attending community college. Additionally, although there were slight differences in the

other constructs of the SMQ, with females being more motivated by factors such as career motivation, these differences are all within one standard deviation of the mean.

STEM has been shown to be of importance in the well-being of both individual students and their communities, but for the greater good of a nation as well. Increasing student motivation in STEM subjects has been a challenge facing administrators, educators, leaders, and parents of high school students. Because of this, this research investigated STEM motivation amongst students who have completed high school and are beginning community college or considering beginning community college using the science motivation questionnaire (SMQ) to assess motivation levels.

The existing literature supports the conclusions drawn by this study which find that students who participate in the arts during high school are more likely to be motivated in STEM subjects during community college (Bandura et. al, 2001; Day, 2016; Smith, 2017 & Wang et. al, 2017). This study only collected data on students who already earned a high school diploma and were interested in achieving community college between the ages of 18 and 24. Therefore, the conclusions drawn may not be comparable to results of similar studies in groups not meeting the same selection criteria.

Conclusions

This study investigated the relationship between self-efficacy gained from participation in the arts during high school and STEM motivation when a student begins community college. The results of the statistical analyses performed in this study provided evidence, which was capable of answering the research questions, and able to affirm that self-efficacy mediates the relationship between student participation in the arts during high school and later STEM motivation when those students begin community college.

Science, technology, engineering, and mathematics (STEM) are subjects of vital importance to the future of a student's future life endeavors, ranging from career choices, civic services to daily domestic and societal tasks. The current differences in STEM motivation between the genders is expected to continue for the immediate future, thus attention is being given by educational leaders on research, such as this study, which seeks to increase overall STEM motivation levels, and to decrease the gap in STEM motivation levels between the genders. Because of these, and other, reasons, parents, teachers, administrators, community leaders and students are all interested in ways in which they can increase student motivation levels in STEM.

Practical implications

The findings of this study allowed for this researcher to draw some practical implications about motivating students towards STEM subjects. Traditionally, research done which studies the influence of what is typically considered non-core educational subjects such as the arts, journalism, sports and other extra-curricular activities is done in a qualitative manner instead of a quantitative manner. While valuable data and insight may be obtained through such observational social science, the findings reported are normally case-specific, sometimes speculatory, and rarely reproducible. Such research does not carry the same weight as reproducible quantitative research to administrators and community leaders who are seeking to maximize student learning in core subjects while remaining under budgetary constraints.

Educational leaders are under societal pressure to increase student performance in the core STEM subjects as measured by standardized exams which vary from state to state. Often legislators require that certain schools and districts meet certain testing thresholds as a condition of receiving governmental funding and in some cases their very jobs. Due to this pressure, when such educators are trying to decide how to increase student STEM performance, they are likely to ignore much of the qualitative research available which investigates how non-core academic studies impact core, STEM education. Contrastingly, if they have quantitative, reproducible research that shows how non-core studies such as the arts produce a tangible, quantifiable, and reproducible positive impact on student motivation and thus performance in the core STEM areas of interest. This research is one of the first quantitative pieces of evidence which shows that student participation in the non-core arts during high school does have a positive correlation with STEM motivation, and that this increase is mediated by self-efficacy.

It is possible that more effort needs to be placed upon the education system by administrators and community leaders on helping female students believe that they are capable of being successful in STEM. The direct positive correlation between participation in the arts and STEM motivation observed by this research may provide administrators and teachers a means of helping certain groups of students believe that they are being capable in STEM, regardless of their demographic and socioeconomic status.

Future implications

These results contribute empirically to the existing body of knowledge on STEM motivation and self-efficacy. This researcher anticipates that in the future, more research will be conducted on how domain specific ability and participation in multiple academic domains may influence student STEM motivation. This study found that the domain of the arts, as expressed by arts participation in high school, could provide the basis for academic administrators and teachers to strongly consider increasing the availability of arts programs to their high school students. This study could be easily reproduced by other researchers, academics, or administrators with even greater levels of precision and specificity. The positive results which were obtained by this research provide a doorway for future researchers to investigate more specific interactions between student academic endeavors and their motivation or attitude towards learning STEM. For example, it is possible that specific arts have more or less influence on self-efficacy. Students who have the discipline to practice a musical instrument several hours a week may develop self-efficacy not just in their musical ability, but also in themselves as a person, and, it is that durable sort of self-efficacy which this research found to be the mediating element in the interaction between arts participation and STEM motivation.

Recommendations for future research.

For the purposes of advancing the body of scholarly literature regarding STEM motivation in high school students, and the effects of self-efficacy as a potential mediator in other cross-domain transfers, this study will now present some opportunities for future research studies. To begin, more quantitative research needs to be conducted regarding student STEM motivation in general. Currently, most of the literature on the topic is qualitative (Akers, 2017; Cogdill, 2015; Elpus, 2011; Fenning et. al, 2013; McDonald, 2016; and Wang et. al, 2017). Various methods to measure student motivation levels, such as the SMQ (Glynn et. al, 2013) have been developed, but are currently only used to directly measure the variables they are developed to measure. More work needs to be done to study potential

mediators and moderators in the relationship between domain-specific student participation in subjects during high school and their STEM motivation levels.

Finally, it is recommended that community leaders and governments work to provide funding for arts programs across the nation. There continues to be a group of underserved students who get little to no exposure to the arts as part of their academic experience. These students often exhibit lower motivation levels towards STEM as well (McDonald, 2015). Therefore, it is recommended that any organization or individual with the means to increase the availability of arts programs in underserved areas where students have little exposure to the arts do so. Such an increase will provide opportunities to students and increase their motivation levels in STEM. Many of the existing barriers preventing students from participating in the arts are financial. These barriers could possibly be eliminated by increasing the availability of funding for arts programs in general, or in a manner targeting underserved demographic groups.

Final Thoughts

The educational journey which students go through as they develop into adults is one which is experienced individually by students and administered collectively by educators. If one visits most major university, they will find that there are various colleges which comprise the campus. There is typically a college of business, one of engineering, another of medicine, and not just a college of sciences, but rather a college of arts and sciences. Ancient civilizations such as the Greeks viewed the arts to be just as fundamental for the human experience in learning about the true nature of reality as the sciences.

Pythagoras helped develop mathematics by exploring how strings of different lengths, when plucked, produced different tones. Based on this synthesis of mathematics and sound, he speculated that the arts was the language in which the Gods spoke (Ball, 2009). The ability for students to participate in the arts should remain a fundamental aspect of education today, just as it has been for many centuries in the past. This researcher hopes that this work provided a small amount of mathematical evidence showing how learning and exploring the arts benefits a student who is also seeking to learn about science.

However, instead of plucking strings like Pythagoras did to produce tones and learn how art and science are interconnected, the plucked strings in this work were electronic surveys bootstrapped by a computer algorithm named PROCESS. Hopefully the sounds produced by this work can be reproduced, just as Pythagorus' strings were, because the goal of quantitative work like this is to discover something fundamental which provides insight into how the universe works and which can be expanded upon or explored by others, regardless of whether they are students plucking the strings for the first time, or learned scholars who seek to study the deeper philosophical meanings of the sounds produced by those strings being plucked.

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