RMLE Online
Research in Middle Level Education

Karen Weller Swanson, Ed.D., Editor
Mercer University
Atlanta, Georgia

2011 • Volume 35 • Number 3 ISSN 1940-4476

# The Effect of an Experiential Learning Program on Middle School Students' Motivation Toward Mathematics and Science

Andrea E. Weinberg
Colorado State University
Fort Collins, CO

Carole G. Basile
University of Missouri
St. Louis, MO

Leonard Albright
Colorado State University

## Abstract

A mixed methods design was used to evaluate the effects of four experiential learning programs on the interest and motivation of middle school students toward mathematics and science. The Expectancy-Value model provided a theoretical framework for the exploration of 336 middle school student participants. Initially, participants were generally positive and had relatively high mathematics and science motivation (Eccles et al., 1983). Overall interest in mathematics increased after completing the program, but a decrease in the importance of mathematics on students' sense of self and some gender differences were detected, with males showing more gains than females. While few significant differences were found on the pre-post student self-ratings, other evidence suggests the program brought about meaningful change. Several potential reasons for the lack of detectable changes on self-reported student motivation measure are discussed. This article concludes with a discussion about the implications for the evaluation of science enrichment programs.

## The Effect of an Experiential Learning Program on Middle School Students' Motivation Toward Mathematics and Science

There is increased need for middle level students to be exposed to stimulating science education (National Council for Educational Statistics [NCES], 2004; National Science Board [NSB], 2006) and for more students, especially females and other members of traditionally underrepresented groups, to be exposed to and experience careers in science (Reis & Park, 2001). With this in mind, it is critical to provide contexts that promote positive gains in the attitudes and motivations of students to learn about the nature of science and become scientifically literate. Formal learning experiences are curriculum driven, associated with grades, and take place within a structured school setting. Informal learning experiences are voluntary, semi-structured, and interest-driven. Informal science enrichment programs are often inquiry-based and aim to emphasize the connections between science and the real world (Freedman, 1997; Parker & Gerber, 2000; Ricks, 2006; Romance & Vitale, 2001). It has been argued that the "world of school science bears little relation to the world outside, where science and technology are everywhere" (Wellington, 1990, p. 250); therefore, informal programs highlighting the real-world applications of science are critical.

A variety of indicators have been used to examine the effectiveness of science enrichment programs. Studies investigating science knowledge acquisition and achievement have illuminated positive effects of enrichment programs on student achievement in science (Freedman, 1997; Houtz, 1995; Parker & Gerber, 2000; Romance & Vitale, 2001). There is an indication that informal learning experiences correspond to higher scientific reasoning abilities (Gerber, Cavallo, & Marek, 2001) and a greater ability to assimilate and understand formal classroom information (Adey & Shayer, 1990). Exposure to voluntary, interest driven learning experiences can increase students' interest in and enthusiasm for science (Jarvis & Pell, 2005; Parker & Gerber, 2000) and can result in changes that continue over time (Rennie, 1994; Wolins, Jensen, & Ulzheimer, 1992). Longer-term studies have found positive effects of informal learning on self-efficacy and participation in science-related activities or courses (Marcowitz, 2004; Redmond, 2000), as well as interest in science-related careers (Marcowitz, 2004). Furthermore, positive experiences in science can lead to continued growth in self-efficacy and confidence (Stake & Mares, 2001).

The Expectancy-Value theory of motivation provides the theoretical framework for this study. Eccles and colleagues take a cognitive perspective in the pursuit to predict why individuals choose to engage in a task. This model is closely related to the Fishbein and Ajzen (1975) theory of Reasoned Action, which assumes one's attitude toward a behavior and one's subjective norm with respect to the behavior predicts that individual's intention to perform that behavior. One's intention to perform a behavior constitutes the best predictor of future behaviors (Fishbein & Ajzen, 1975). The Expectancy-Value theory draws on the theory of Reasoned Action and on the work of Atkinson (1957) and Weiner (1985) to apply these models to educational contexts. At the heart of the Expectancy-Value theory are student expectations for success and the relative value they ascribe to a task. Expectations for success refer to an individual's beliefs about the consequences of actions. These expectations affect behavior, in that, if students believe they will not succeed or are concerned with negative consequences of failure, they are less likely to participate in the activity. Value relates to student beliefs regarding the importance or usefulness of what they will learn. If a student values an activity or a topic, they are more likely to show interest and engage in the activity (Wigfield & Eccles, 2002). Wigfield and Eccles also illustrate how expectancy behavior relates to other constructs such as self-efficacy, self-concept, motivation, perceived control and self-competence. Research has demonstrated the predictive value of expectations on achievement (Boe, May, & Bourch, 2002; Dweck & Sorich, 1999) and academic-related choices such as course selection and course taking (Casey, Nuttall, & Pezaris, 1997; Frome & Eccles, 1998; Jacobs, Finken, Griffin, & Wright, 1998). Specifically, motivation affects intellectual performance and the construction of knowledge (Sinatra & Pintrich, 2003) as well as the type of cognitive strategies employed when faced with a challenge (Elliot, McGregor, & Gable, 1999; Grant & Dweck, 2003). Student interest in science is associated with increased student attention to formal instruction and more participation in science activities or courses (Farenga & Joyce, 1999; Farmer, Waldrop, & Rotella, 1999; Germann, 1988; Marcowitz, 2004). Furthermore, Simpkins, Davis-Kean, and Eccles (2006) demonstrated that early involvement in math and science activities can be linked to future mathematics course-taking. Choices regarding course selection and participation in high school science courses influences students' postsecondary and career options. Knowledge regarding changes in task value related to mathematics and science will allow for speculation about the possibilities of influencing choice outcomes (future course enrollment) and performance outcomes (achievement in science) that could result from participation in a summer program. A reciprocal relationship is thought to exist between expectancy beliefs and task value beliefs (Pintrich, 2003; Schunk, 1995). Therefore, if participation in a summer program results in an increased expctation for success, then value beliefs will also increase, and vise-versa. An additional reciprocal relationship between educational choices or behaviors (e.g., enrollment in a course) and beliefs was found by Simpkins and associates (2006).

## Context

The summer science enrichment programs that are the focus of this study are a collaborative Math and Science Partnership (MSP) effort among five higher education institutions, seven school districts, and one educational cooperative in a metropolitan area in the Rocky Mountain region. This collaboration has been funded by the National Science Foundation (NSF) since 2004. The purpose of the partnership is to increase student achievement in grades 6 through 8. The primary focus of the MSP is to provide professional development for middle school teachers to impact student learning through more effective instruction in mathematics and science. Teachers participate in both content courses and structured follow-up courses. A secondary but equally significant focus is developing and supporting opportunities for middle level students, grades 5 through 9, to engage in activities to promote science and mathematics achievement.

The outreach and intervention initiative in this project targets students from minority and economically disadvantaged communities within the partner school districts. Up to 1,000 students could be served across the four programs each year of the MSP. While the summer camps are voluntary and students from partner school districts are welcome, those who meet the criteria free and reduced-price lunch are particularly encouraged to attend. One district used the summer camps as an opportunity to engage students as an alternative to the district's summer school program. Others provided transportation for students as a way to encourage participation.

Summer science and mathematics outreach programs supported by this MSP are on the campuses of the four collaborating universities. Students from the seven cooperating school districts are able to attend the programs at no cost. A unique aspect of the partnership is the fact that some form of each of the summer programs was in existence prior to the current sponsorship by the MSP. By tapping into these established sites, this MSP project was able to forgo many of the organizational complexities associated with initial start-up of educational enrichment programs.

Two institutions offered one- to two-week residential programs on their respective campuses. Combined, these two universities offered a total of six summer programs ranging in size from 23 to 40 students. For the most part, each residential program focused on a single topic. Topics included: (a) artificial intelligence; (b) climate change; (c) renewable energy; (d) mathematics, wildfire ecology, physics, and agro-ecology; and (e) astronomy. The remaining two universities offered one to two week commuter (non-residential) programs. At one institution, two half-day sessions were offered each day; students could attend either the morning or afternoon session. Each session was three hours in length and focused on a variety of topics that included: (a) human biology, (b) mathematics, (c) microbiology, (d) chemistry, (e) geology, (f) physics, and (g) geology. The second university to offer commuter summer programs offered a combination of full- and half-day programs, each focused on one of six different topics: (a) global positioning systems (GPS), (b) crime scene investigation (CSI), (c) air quality, (d) science for the environment, (e) robots and artificial intelligence, (f) the physics of everyday things, and (g) extreme media.

## Method

### *Participants*

The sample consists of 336 middle level students who attended a mathematics and science summer program, in 2008 or 2009, at one of the four cooperating higher education institutions. All students who attended a summer program and completed the Science and Mathematics Student Attitude Assessment Survey (SMBMA), both at the beginning and the end of the program, were included. The demographic representation of the participants is shown in Table 1.

### *Research Questions*

Table 1
*Demographic Characteristics of Participants*

| **Characteristic** | *n* | % |
|---|---|---|
| Gender | | |
| Male | 158 | 47 |
| Female | 176 | 53 |
| Ethnicity | | |
| Minority | 180 | 54 |
| Non-Minority | 153 | 46 |
| Usual Grades | | |
| As and Bs | 277 | 80 |
| <As and Bs | 65 | 20 |
| Year in School | | |
| Grade 6 | 47 | 19 |
| Grade 7 | 63 | 25 |
| Grade 8 | 77 | 31 |
| Grade 9 | 35 | 14 |
| Grade 10 | 12 | 5 |
| Grade 11 | 11 | 4 |
| Grade 12 | 3 | 1 |
| Type of Summer Program | | |
| Residential | 74 | 41 |
| Commuter | 106 | 59 |

*Note:* $n$ = 336

In response to the key components of the summer science and mathematics programs, the following research question was asked: To what extent do the mathematics and science summer programs affect students' motivation toward mathematics and science? Quantitative and qualitative methods were used to explore student motivation before and after completing the summer program to (a) compare the two types of programs, residential and nonresidential; (b) examine differences in motivation change based on student characteristics; and (c) explore changes in students' understanding of what mathematicians and scientists do.

***Measures***

Multiple data collection tools were used, including the Science and Mathematics Student Attitude Assessment Survey, a Student Interview Guide, and an Instructor Online Questionnaire. Each of these is explained briefly below.

***Science and Mathematics Student Attitude Assessment.*** Student attitudes toward science and mathematics were measured using two versions of the Science and Mathematics Student Motivation Assessment (SMSMA) survey. The pretest was administered on the first day of each summer program, and the posttest was given on the final day. The SMSMA was adapted from Conley and Karabenick's (2006) Student Motivational Survey (SMS). The SMSMA questionnaire included 44 individual Likert items. These items were used to create five composite indices that serve as indicators of "task value" in Eccles and associates' Expectancy-Value Model: *interest value, utility value, cost value,* and *attainment value,* as well as *expectancy for success*. The expectancy for success index was added the second year of the evaluation to better align the instrument with the theoretical model. Reliability analyses conducted on data from this study found adequate to high Cronbach's alphas ranging from .84 to .96. These reliability findings are consistent with those found on the original instrument (Conley & Karabenick, 2006) and on an adapted version of this instrument on another NSF funded project (Weinberg, Albright, & Wolgemuth, 2009).

Half of the SMBMA's Likert-type items are related to mathematics and half to science. Each of the questions that comprise the dimensions of task value and expectancy for success were asked twice; the first set of 22 items is related to mathematics, and the second set of 22 items is related to science. Each of the five indices was measured for both mathematics and science, for a total of ten composite indices that are defined as follows:

1. Interest Value (5 questions): The level of student interest and excitement. (e.g., 'I enjoy doing math [science].' 'Math [Science] is exciting to me.')

2. Utility Value (6 questions): Students' beliefs regarding the usefulness of studying the subject (e.g., 'What I learn in math [science] will be useful to me later in life.').

3. Cost Value (2 questions): Student beliefs about the requisite effort involved in being a successful student in the particular area of study (e.g., 'I have to give up a lot to do well in math [science].').

4. Attainment Value (4 questions): The importance of the subject on the student's sense of who they are (e.g., 'Being good at math [science] is an important part of who I am.').

5. Expectancy for Success (5 questions): Students' expectations for future success (e.g. 'In the future, I think I will do well in math [science].').

In addition to the examination of the composite indices, responses to two post-test items, "Did this module decrease or increase your interest in math?" and "Did this module decrease or increase you interest in science?" were examined. Students were asked to respond to these using a 5-point Likert scale (1= decrease, 2 = slight decrease, 3 = no change, 4 = slight increase,5 = increase). Very few respondents indicated either 2 or 4 on these items, which led researchers to recode each of these two items into a 3-level variable (increase, no change, decrease) and use these as a qualitative measure of student self-reported influence on mathematics and science interest.

***Student interview guide.*** A student interview guide was used for interviews with three students at each site. Researchers inquired about the student's level of interest in mathematics and science, the influence of the summer program on their mathematics and science motivation, and program highlights and low points.

***Design and Procedure***

The rationale for using a mixed methods design is threefold. First, the exploration of outreach programs from multiple perspectives with a combination of quantitative and qualitative data offsets the limitations inherent in the use of only one data collection strategy. Second, this approach allowed the researchers to consider a more diverse set of research questions. Third, the integration of the two approaches enabled the combination of statistical analyses with rich interviews and thematic analysis (Creswell & Clark, 2006).

General research procedures at each site were identical. The research involved four data collection procedures: (a) student pre- and post-motivation assessment, (b) onsite observation, and (c) student interviews. On the first and last day of each program, the SMSMA questionnaire was completed by each student. A one-day observation at each of the sites provided a combined student and instructor contextual assessment. This observation allowed an opportunity for researchers to observe the program session and provided an opportunity to conduct formal interviews with students and instructors at each site. Instructors assisted in the purposeful selection of three students to participate in interviews. Students were selected to maximize the variation in the sample to include a student (a) who is completing the course with relative ease, (b) who is adequately progressing through the course, and (c) who is experiencing difficulty with the course. An interview guide was used as a starting point, but students were encouraged to elaborate freely.

## Results

The SMSMA was used as the primary instrument to assess student attitudes related to mathematics and science interest, utility, cost value, and attainment value at the beginning and upon completion of the summer program. Additional items on the SMSMA posttest were used as student self-reported measures of interest and understanding. Data gathered during student interviews were used to expand upon and further describe the experiences and attitudes of students. Outlined below are results of this data collection based on 336 matched pre- and post-SMSMA instruments and 24 student interviews.

### *Overall Scores*

An examination of the average pre-SMSMA Likert-scale scores for each of the ten composite indices indicated a generally high level of student motivation toward mathematics and science upon entering the summer program. The mathematics *interest* mean score was somewhat high, $M = 3.6$; the mathematics *utility* mean score was very high, $M = 4.4$; and the mathematics *attainment value* mean score was also reported as somewhat high, $M = 3.7$. Students were neutral about mathematics cost value, $M = 2.9$. Science indicators were even more positive, with a high level of science *interest*, $M = 4.3$; high view of science *utility*, $M = 4.1$; and high science *attainment value*, $M = 3.8$. Students did not have any strong opinions about the *costs* associated with achievement in science, $M = 3.1$. These levels of student motivation toward mathematics were a great deal higher than found when using a modified version of this instrument with other groups of students, which could be expected, since these students chose to participate in a summer enrichment program (Weinberg, Albright, & Wolgemuth, 2009; Wolgemuth, Guenther, Fritz, & Albright, 2008).

The pretest composite indices were compared with their corresponding posttest scores. Results of a paired samples *t*-test or a non-parametric Wilcoxen Signed Ranks Test (as appropriate) for each of the eight indices indicate a significant difference in mathematics *interest*, *attainment value*, and *expectancy for success*. As shown in Table 2, after completing the program student responses reveal a significantly higher level of *interest* in mathematics than indicated on the pretest completed upon entering the program, $t(334) = 5.00$, $p > .01$. Interestingly, students reported a significantly lower mathematics *attainment value*, or sense of the importance of mathematics on who they are after completing the program, than they indicated prior to the program, $t(324) = -2.15$, $p = .03$. Finally, student expectations for future success in mathematics increased significantly, $t(155) = -2.04$, $p = .05$. Although students were more interested in mathematics and confident in their ability to succeed after the summer science and mathematics program, they did not similarly identify that success in mathematics helped them define their sense of self. The following supposition is possible: A student's level of interest in mathematics or science could increase but how that individual defines her/himself does not. This could mean that mathematics or science was no longer viewed to have as strong a connection to what the individual uses to characterize his or her sense of self.

Greater gains were realized in science than in math. No differences were found, and students remained neutral about the perceived costs associated with being successful in science. Significant gains were realized on all other indicators of task value and on expectations for success. Student interest in science increased, $z = 2.54$, $p =.01$; as did student perceptions of the usefulness of science, $t(332) = -2.59$, $p =.01$; the importance of science on how students define themselves, $t(331) = -2.05$, $p = .04$; and expectations for future success in science, $t(154) = -2.39$, $p = .02$). These greater gains in science were not surprising, as the primary focus of the camps was science.

Table 2
*Student Motivation Scores on Pretest and Posttest SMSMA*

| | Pretest | | Posttest | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *df* | Stat. | *p* |
| **Mathematics** | | | | | | | |
| Interest | 3.61 | 1.10 | 3.78 | 1.09 | 334 | 5.0[a] | <.01** |
| Utility | 4.41 | .60 | 4.34 | .71 | N/A | -1.82[b] | .07 |
| Cost Value | 2.91 | 1.48 | 2.96 | 1.55 | 335 | .91[a] | .37 |
| Attainment Value | 3.73 | .97 | 3.64 | 1.08 | 324 | -2.15[a] | .03* |
| Expectancy for Success | 3.89 | .83 | 3.99 | .87 | 155 | 2.04[a] | .05* |
| **Science** | | | | | | | |
| Interest | 4.34 | .71 | 4.35 | .82 | N/A | 2.54[b] | .01** |
| Utility | 4.02 | .85 | 4.11 | .88 | 332 | 2.59[a] | .01** |
| Cost Value | 3.06 | 1.59 | 3.03 | 1.65 | 320 | .65[a] | .52 |
| Attainment Value | 3.65 | 1.04 | 3.74 | 1.07 | 331 | 2.05[a] | .04* |
| Expectancy for Success | 3.89 | .96 | 4.00 | .88 | 154 | 2.39[a] | .02* |

*Note:* [a] = *t*-Statistic; [b] = Wilcoxon Signed Ranks test-statistic (non-parametric test), *= $p \leq .05$, **= $p \leq .01$

***Commuter Versus Residential Programs***

Matched pre- and post-SMSMA instruments were available for 146 students who attended commuter, or non-residential, programs and 190 students who attended residential summer programs. When gain scores (the difference between pretest and posttest values) were calculated and compared, students in both types of programs indicated similar levels of mathematics and science interest, utility, cost value, and attainment value upon entering the program. Results of independent samples *t*-tests comparing gain scores from those attending residential and commuter programs on each of these indices are shown in Table 3. A significant difference in mathematics *utility value* was found when student gain scores of those who attended residential programs were compared to those who attended commuter programs, $t(251.1) = -3.02$, $p > .01$. Students who attended residential programs showed an increased difference in their perceptions of the usefulness of mathematics. This could be due, in part, to a greater focus on mathematics by the residential programs. It is important to note that overall, as described previously, the mathematics *utility value* for all students combined did not show a significant increase or decrease over the course of the program. Additional analysis indicates that non-minority and minority students were equally likely to attend residential and commuter programs, $\chi^2(1, N = 333) =.001$, $p = .97$. Female students were more likely to attend residential programs than male students, $\chi^2(1, N = 334) =10.15$, $p < .01$. It is unclear if this is due to student preference or recruitment differences.

The experiences described by residential program and commuter program participants were different. Responses to open-ended SMSMA items were also noticeably different for these program participants. Variances indicate program differences not detected by the SMSMA Likert-type items. Commuter participant responses were brief, as in “It was fun” and “I learned a lot.” Residential participants’ comments were more detailed and spirited. Comments included “This camp is the best I’ve ever been to and the mentors helped us reach our goal with enjoyment and fun.” and “It is a good hands-on way to learn, meet new people, and gain experience.” Comments such as “You get to see what life outside your own house is like.” and “I like the opportunity to learn and make friends. … I got to know the other kids better because everyone is here and working hard. It is in-depth learning.” suggest lessons learned during the residential programs extend beyond mathematics and science topics. Although, residential participants noted feelings of homesickness, they were less likely to report being bored than those attending commuter programs.

### *Ethnicity*

As shown in Table 4, changes regarding mathematic or science motivation factors between non-minority and minority students were not significant. An independent sample t-test indicated no differences in gain scores between minority students and non-minority students. The summer science and math programs have a similar influence on non-minority and minority students.

### *Gender*

Males and females were equally represented in the summer programs, and there were no significant differences between males and females on any of the indicators of mathematics or science task value or expectancies for future success upon entering the summer program. Students of both genders (a) entered the program with some interest in mathematics and science, (b) thought these topics were useful, (c) noted that mathematics and science played a role in how they defined themselves, (d) were generally neutral about the costs associated with being good at these subjects and had relatively high expectations for their future academic success. After the program, as shown in Table 5, similar gains for both male and female students were seen on all indicators of task value and expectancies for future success. No significant differences were noted, indicating that the programs were equally successful for girls and for boys.

Table 3
*Commuter Program and Residential Program Participant Motivation*

| | **Commuter** | | **Residential** | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *df* | *T* | *p* |
| **Mathematics** | | | | | | | |
| Interest Gain | .14 | .66 | .18 | .57 | 333 | .64 | .52 |
| Utility Gain | -.19 | .70 | .02 | .50 | 251.1 | 3.0 | <.01* |
| Cost Value Gain | .07 | .97 | .21 | .88 | 334 | 1.42 | .15 |
| Attainment Value Gain | -.11 | .81 | -.07 | .72 | 334 | .39 | .70 |
| Expectancy for Success | .18 | .71 | .06 | .52 | 53.9 | .97 | .34 |
| **Science** | | | | | | | |
| Interest Gain | .04 | .58 | .12 | .60 | 332 | 1.16 | .25 |
| Utility Gain | .06 | .69 | .12 | .63 | 331 | .89 | .37 |
| Cost Value Gain | .04 | .78 | .04 | .85 | 319 | .05 | .96 |
| Attainment Value Gain | .11 | .75 | .07 | .77 | 330 | .42 | .68 |
| Expectancy for Success | .16 | .88 | .12 | .61 | 52.5 | .27 | .79 |

*Note:* ** = $p \leq .01$

***Level of Interest***

Responses to two SMSMA posttest items, *self-reported influence on mathematics interest*, and *self-reported influence on science interest* were examined. Overall, the vast majority of students reported increases in mathematics interest due to the program, $n = 207$, 62%, some reported that it had no influence on their level of interest in mathematics, $n = 101$, 30%, and few said that the program caused their level of interest in mathematics to decrease $n = 18$, 6%. When asked if the program influenced their level of interest in science, 262 students (85%) responded that the program increased their level of interest in the subject.

In addition to this overall examination of the self-reported impact of the program on students' level of science and mathematics interest, analysis of sub-populations by gender and ethnicity was examined. There was no difference in the proportion of males (87%, $n = 135$) and females (83%, $n = 151$) who responded that their experience in the program increased their level of science interest, $\chi^2$ (2, $n = 307$) = .95, $p = .62$. Similarly, the proportion of males (63%, $n = 97$) and females (65%, $n$ =109)who reported an increase in their interest in mathematics as a result of the program was not found to be significantly different, $\chi^2$(2, $n = 324$) = .24, $p = .89$). A statistically significant difference was found between non-minority and minority student responses. Minority students' level of mathematics interest increased as a result of their participation in the program $\chi^2$ (2, $n = 323$) = 6.42, $p = .04$. Minority students' increase in mathematics interest ($n = 120$, 69%) was greater than non-minority students' ($n = 84$, 56%). Non-minority and minority students reported equal increases in science interest $\chi^2$(2, $n = 306$) = 3.53, $p$ =.17.

Remarks such as "It showed me that math isn't just a pointless thing, and it is used for lots of things" provide evidence of increased awareness as to the importance of mathematics and science and their application. Other comments related to the integration of mathematics and science topics include "This camp gave me a better understanding of how gathering data and making patterns, a science thing, can also be used in math." and "It showed me a lot more of what you can do with science and math." and lessons about the scope of math and science, such as "Everything has to do with science/math." One student reported attendance at a prior year's camp improved her school performance stating, "I feel I did better and learned a lot in school after coming last year. I think this year I will do even better." These and similar comments validate the responses to the direct SMSMA post-test items discussed previously, *self-reported influence on mathematics interest*, and *self-reported influence on science interest.*

Table 4
*Non-Minority and Minority Student Motivation*

| | **Non-Minority** | | **Minority** | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *df* | *T* | Sig |
| **Mathematics** | | | | | | | |
| Interest Gain | .16 | .59 | .16 | .63 | 330 | .04 | .97 |
| Utility Gain | -.63 | .57 | -.09 | .63 | 331 | .35 | .73 |
| Cost Value Gain | .16 | .82 | .15 | 1.01 | 331 | .09 | .93 |
| Attainment Value Gain | -.08 | .72 | -.10 | .80 | 331 | .15 | .88 |
| Expectancy for Success | .09 | .55 | .09 | .60 | 152 | -.06 | .95 |
| **Science** | | | | | | | |
| Interest Gain | .09 | .54 | .08 | .64 | 329 | .21 | .83 |
| Utility Gain | .12 | .59 | .07 | .70 | 325 | .60 | .55 |
| Cost Value Gain | .04 | .77 | .05 | .87 | 316 | -.08 | .94 |
| Attainment Value Gain | .11 | .69 | .07 | .82 | 327 | .74 | .64 |
| Expectancy for Success | .22 | .63 | .05 | .72 | 151 | 1.56 | .12 |

 

Table 5
*Male and Female Student Motivation*

| | Male | | Female | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *df* | *T* | Sig |
| **Mathematics** | | | | | | | |
| Interest Gain | .16 | .60 | .17 | .62 | 331 | -.14 | .89 |
| Utility Gain | -.09 | .59 | -.06 | .61 | 332 | -.53 | .60 |
| Cost Value Gain | .19 | .86 | .12 | .98 | 332 | .72 | .47 |
| Attainment Value Gain | -.12 | .78 | -.06 | .74 | 332 | -.71 | .48 |
| Expectancy for Success | .00 | .67 | .16 | .50 | 152 | -1.72 | .09 |
| **Science** | | | | | | | |
| Interest Gain | .06 | .63 | .11 | .56 | 330 | -.69 | .49 |
| Utility Gain | .15 | .63 | .04 | .68 | 329 | 1.59 | .11 |
| Cost Value Gain | -.02 | .90 | .10 | .74 | 317 | -1.2 | .21 |
| Attainment Value Gain | .13 | .74 | .04 | .78 | 328 | 1.08 | .28 |
| Expectancy for Success | .05 | .69 | .18 | .68 | 151 | -1.09 | .30 |

Finally, students responded to a series of career-related questions. When asked if the camp changed their understanding of what mathematics and scientists do, 277 (84%) responded "yes". Specific comments such as "I never thought of firefighters as mathematicians." and "I learned a lot about the behind the scenes work that scientists and mathematicians do and how it affects my daily life." and "It changed my attitudes of scientists because now I know exactly what they do. Before I was confused about exactly what they did." demonstrate that some students came away with more precise notions of what mathematicians and scientists do. Other responses show that the program expanded students' views of mathematics and science: "I didn't think science was more than just class work." and "It showed me that math isn't just a pointless thing, and it is used for lots of things." Others expressed a newfound appreciation for the complexity of science and mathematics careers, as evidenced by comments such as "I thought their [mathematicians and scientists] job was easy but it's not." Of those who stated that the program did not change their understanding, many related that they already knew about the topics presented and about what scientists and mathematicians do.

Students reported two careers available to mathematicians and two careers available to scientists. Careers in the broad fields of business/finance (e.g., banker, accountant, cashier), education (e.g., teacher, professor), engineering (e.g., electrical engineer), and science (e.g., biologist, chemist) were most often cited for mathematicians on both pre- and post-assessments. Scientist was the most common response provided for science careers. A majority of students listed specific science careers (i.e., biologist, astronomer) rather than general 'scientist' on pre- and post-assessments. Science careers in the broad fields of education and medicine were additionally reported. There were no appreciable changes in the percentages of students' broad category examples. Evidence indicating that students were able to identify a greater assortment of careers upon completion of the program was insufficient. Post-program assessment responses did not reveal increased student awareness of available mathematics and science careers. However, self-reported, post-program comments suggest increased student understanding of the various professional roles of a mathematician or scientist.

## Discussion

The research findings add insight to the limited knowledge regarding benefits of young adolescents' participation in specialized science and mathematics summer programs. Results provide increased understanding of discipline-focused summer camp programs' impact on participants' mathematics and science motivation. Social and educational benefits were especially evidenced in traditionally underrepresented science program participants. Although student outcomes were measured in short term, the findings support additional, longitudinal summer camp program research.

A ceiling effect was observed on the SMSMA, with 50% of students reporting a five on the Likert scale items pertaining to interest in mathematics. The preponderance of high level of motivation and understanding of the importance of mathematics and science responses reported on the SMSMA pretest limited posttest change measurement. Responses to open-ended SMSMA items and interview question indicate a high level of participant engagement in the summer programs and intense motivation to learn and improve skills. Frequency of high level of interest pre-test responses contributed strongly to less detection of posttest changes in participant interest. This questionnaire is aligned with the Expectancy Value model of motivation and has proven a sound measure in other studies. Findings indicating high levels of motivation to succeed in mathematics and science were unexpected. An additional plausible cause for the lack of changes between the pretest and posttest responses could be the result of depressed posttest scores resulting from short-term shifts in students' self-perceptions. Sax's (1994) study suggests that when part of a new talented peer group, students' frame of reference is altered, thus causing students to rate themselves lower because of this new reference group.

Furthermore, the duration of the programs and the timing of assessments may have contributed to the lack of reported response changes. Hovland, Janis, & Kelley (1953) theorized that persuasive messages intended to produce attitude changes have a delayed impact. In their recent work on science enrichment programs and their influence on student motivation, Stake and Mares (2005) refer to this phenomenon as the ”splashdown effect”. Therefore, realization of attitudinal changes may require increased passage of time.

## Directions for Future Study

Fredericks and Eccles (2006) supported increasing opportunities for adolescents to participate in a range of extracurricular activities. Contexts can include learning environments with distinct "opportunity structures" for developing personal and interpersonal skills. Extracurricular contexts allow students to engage in activities that demonstrate a wider range of skills and interests in comparison to most academic settings. However, acknowledgement is afforded to possible long-term effect limitations of summer camp experiences; in particular, they are not supported by a social environment that follows up, promotes, and encourages students to continue their studies. Therefore, important future inquiry should include longitudinal assessment of summer program participant's academic choices and achievement. Other opportunities for future research include conducting interviews with parents and family members to ascertain levels of math and science support before and after a student's participation in the camp to examine why students chose to participate in the camp experience and to increase understanding of initial high motivation levels and value scores. The results of this study are encouraging; especially the numbers of high-need students who chose to participate when access, funding, and transportation needs were met. Findings that indicate any students enter summer programs with high motivation and subsequently experience increased motivation over the course of the program offer positive prospects for experiential learning advocates.

 

## References


Adey, P., & Shayer, M. (1990). Accelerating the development of formal thinking in middle and high school students. *Journal of Research in Science Teaching, 27*, 267–285.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review, 64*, 359–372.

Boe, E., May, H., & Boruch, R. (2002). *Student task persistence in the third international mathematics and science study: A major source of achievement differences at the national, classroom, and student levels*. Retrieved from ERIC database. (ED498566)

Casey, M., Nuttall, R., & Pezaris, E. (1997). Mediators of gender differences in mathematics college entrance test scores: A comparison of spatial skills with internalized beliefs and anxieties. *Developmental Psychology, 33*(4), 669–680.

Conley, A. M., & Karabenick, S. A. (March, 2006). *Construct validity issues in the measurement of motivation to learn*. Paper presented at the Society for Research on Adolescence, San Francisco, CA.

Creswell, J. W., & Clark, V. L. P. (2006). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Dweck, C. S., & Sorich, L. (1999). Mastery-oriented thinking. In C. R. Snyder (Ed.), *Coping: The psychology of what works* (pp. 232–251). New York, NY: Oxford University Press.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., & Meece, J. L. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75–146). New York, NY: W. H. Freeman.

Elliot, A. J., McGregor, H. A., & Gable, S. (1999). Achievement goals, study strategies, and exam performance: A mediational analysis. *Journal of Educational Psychology, 91*, 549–563.

Farenga, S. J., & Joyce, B. A. (1999). Intentions of young students to enroll in science courses in the future: An examination of gender differences. *Science Education, 83*, 55–75.

Farmer, H. S., Waldrop, J. L., & Rotella, S. C. (1999). Antecedent factors differentiating women and men in science/non-science careers. *Psychology of Women Quarterly, 23*, 763–780.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intentions, and behavior: An introduction to theory and research*. Boston, MA: Addison-Wesley.

Freedman, M. (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*(4), 343–357.

Frome, P. M., & Eccles, J. S. (1998). Parents' influence on children's achievement-related perceptions. *Journal of Personality and Social Psychology, 74*(2), 435.

Gerber, B., Cavallo, A., & Marek, A., (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education, 23*(5), 535–549.

Germann, P. J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching, 25*(8), 689–703.

Grant, H., & Dweck, C. S. (2003). Clarifying achievement goals and their impact. *Journal of Personality and Social Psychology, 85*(3), 541–553.

Houtz, L. E. (1995). Instructional strategy change and the attitude and achievement of seventh- and eighth-grade science students. *Journal of Research in Science Teaching, 32*(6), 629–648.

Hovland, C. I., Janis, I. L., & Kelley, H. H. (1953). *Communication and persuasion.* New Haven, CT: Yale University Press.

Jacobs, J. E., Finken, L. L., Griffin, N. L., & Wright, J. D. (1998). The career plans of science-talented rural adolescent girls. *American Educational Research Journal, 35*, 681–704.

Jarvis, T., Pell, A. (2005). Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre. *Journal of Research in Science Teaching, 42*(1), 53–83.

Markowitz, D. G. (2004). Evaluation of the long-term impact of a university high school summer science program on students' interest and perceived abilities in science. *Journal of Science Education and Technology, 13*(3), 395–407.

National Council for Educational Statistics (NCES). (2004). *Highlights from the trends in international mathematics and science study (TIMSS) 2003.* Washington, DC: U.S. Department of Education.

National Science Board (NSB). (2006). *Science and engineering indicators 2006* (NSF Publication No. NSB 06-01B). Washington, DC: U.S. Government Printing.

Parker, V., & Gerber, B. (2000). Effects of a science intervention program on middle-grade student achievement and attitudes. *School Science and Mathematics, 100*(5), 236–242.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of educational Psychology, 95*(4), 667–686.

Redmond, A. (2000). Science in the summer. *Science Scope, 24*(4), 28–33.

Reis, S. M., & Park, S. (2001). Gender differences in high-achieving students in math and science. *Journal for the Education of the Gifted, 25*, 52–73.

Rennie, L. J. (1994). Measuring affective outcomes from a visit to a science education centre. *Research in Science Education, 24*, 261–269.

Ricks, M. M. (2006). *A study of the impact of an informal science education program on middle school students' science knowledge, science attitude, STEM high school and college course selections, and career decisions.* (Doctoral dissertation) Retrieved from https://www.lib.utexas.edu/etd/d/2006/ricksm81757/ricksm81757.pdf

Romance, N. R., & Vitale, M.R. (2001). Implementing an in-depth expanded science model in elementary schools: Multi-year findings, research issues, and policy implications. *International Journal of Science Education, 23*(4), 373–404.

Sax, L. J. (1994). Mathematical self-concept: How college reinforces the gender gap. *Research in Higher Education, 35*(2), 141–166.

Schunk, D. H. (1995). Self-efficacy and education and instruction. *Self-efficacy, adaptation, and adjustment: Theory, research, and application*, 281–303.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*(1), 70–83.

Sinatra, G. M., & Pintrich, P. R. (2003). The role of intentions in conceptual change learning. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 1–18). Mawah, NJ: Erlbaum.

Stake, J. E., & Mares, K. R. (2001). Science enrichment programs for gifted high school girls and boys: Predictors of program impact on science confidence and motivation. *Journal of Research on Science Teaching*, *10*, 1065–1088.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 92*(4), 548–573.

Wellington, J. (1990). Formal and informal learning in science: The role of the interactive science centres. *Physics Education, 25*, 247–252.

Wigfield, A., & Eccles, J. S. (2002). The development of competence beliefs, expectancies for success, and achievement values from childhood through adolescence. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 91–120). San Diego, CA: Academic Press.

Weinberg, A. E., Albright, L., & Wolgemuth, J. R. (2009). Student attitude change and the *Epidemiology Modules: BioMath student attitude report #2: Year 2 field-test evaluation program*. Fort Collins, CO: Colorado State University.

Wolgemuth, J., Guenther, D., Fritz (Weinberg), A. E., & Albright, L. (2008). *Student attitude change and the computational biology modules Biomath student attitude report #1: Year 1 field-test evaluation program*. Fort Collins, CO: Colorado State University.

Wolins, I. S., Jensen, N., & Ulzheimer, R. (1992). Children's memories of museum field trips: A qualitative study. *Journal of Museum Education, 17*, 17–27.