AC 2011-2446: EFFECTS OF ENGAGING CLASSROOM STRATEGIES AND TEACHER SUPPORT ON STUDENT OUTCOMES OVER SCHOOL TRANSITIONS

Joan Barth, University of Alabama

Joan Barth is a research social scientist at the University of Alabama. Research interests include psychological and educational issues in school settings. Current projects include a study of personal, social and life goal factors that affect interest in STEM careers from elementary through college years.

Debra M. McCallum, University of Alabama
Beth Todd, University of Alabama

Dr. Beth Todd is an Associate Professor of Mechanical Engineering at the University of Alabama.

Rosanna E. Guadagno, University of Alabama
Beverly Roskos, University of Alabama
Dr. Carmen Burkhalter, The University of Alabama

As Senior Associate Dean in the College of Arts and Sciences At The University of Alabama, I am liaison to the College's harassment officials (sexual and otherwise). As Senior Information Officer I systematically analyze the technology needed for all faculty to succeed in the classroom and in their research. In addition, I analyze the availability of technology for student for class work and research and have addressed significant digital divide issues. In an equitable fashion I have made more technology available to faculty, graduate students, and undergraduate students.

Prof. Marion J Goldston, University of Alabama

Effects of Engaging Classroom Strategies and Teacher Support on Student Outcomes Over School Transitions

Abstract

Recruitment of students into engineering undergraduate programs depends to a large degree on maintaining their achievement and interest in math and science over the school years prior to college. Previous research indicates that significant declines in perceived ability and interest in math and science occur during the transitions to middle school and high school. Self-perceptions and attitudes are often reported to be lower at these points for girls than boys. We present an empirical investigation of the effect of students' perceptions of teacher support and classroom strategies on student interest and efficacy in math and science during middle school and high school transitions. Results suggest that students who perceived their teachers as practicing more effective instruction (more support for students, more engaging classroom strategies) were less likely to show declines in their interest and efficacy in math and science as they made these critical transitions.

Introduction

Recruitment of students into engineering undergraduate programs depends to a large degree on maintaining their achievement and interest in math and science over the school years prior to college. Unfortunately, declines in self-perceptions of ability and interest in math and science over the course of schooling are well documented, especially during the transitions to middle school and high school.[3,5,9,11,12,16,21,22] Seminal works by Eccles, Midgely, and colleagues[5,16] describe cognitive and achievement changes during the transition to junior high (at about 12 years of age). Attitudes toward math significantly declined for both boys and girls over the transition to junior high (in contrast to English) and continued to decline over the first year of junior high school. Gender differences were also prominent: Both before and after the transition, boys had better math self-concepts than girls. Similar patterns are apparent in research on the transition to high school[14] such that girls who had better grades than boys still had poorer self-concepts. However, the gender gap in math self-concept does decrease over school years.[6]

Several studies have examined factors that might explain why some students perform better during transitions than others, primarily identifying personal attribute characteristics such as achievement, ability perceptions, self-efficacy, achievement goals, and attitudes.[2,12,22] Ma and Wilms'[12] findings from the *Longitudinal Study of American Youth* (LSAY) indicated that most adolescents drop from advanced math courses during two critical transitions: from eighth grade to high school and from eleventh to twelfth grade. At the transition to high school, dropping out was attributed primarily to prior achievement, but dropping out during high school was attributed to negative attitudes toward math. At this latter time point the dropout rate for girls was greater than it was for boys. Math-capable students who choose to drop from taking advanced math courses in high school are, in all likelihood, choosing not to pursue engineering as a college major or a career.

The Eccles et al.[4] *stage-environment fit* model proposes that school transitions negatively affect academic outcomes because children's developmental needs are not easily met in the social context of post-elementary schools.[10] Each school transition marks a significant decline in teacher support and a change to a more peer-competitive school setting, and this may account for some of the decline in student self-perceptions and attitudes. For example, in contrast to elementary schools, middle schools are characterized as having less supportive teachers, more ability-grouped classes, and more aggression.[4,19,20] The high school setting is even less personal, more competitive, and more grade oriented. Ability differences are emphasized even more as the differences between college bound and other students are more salient.[9] Although not a change in setting, the last two years of high school mark a significant period of preparation for the next academic transition as students take college entrance exams, explore post-high school education, and select courses based on post-high school plans.

These three transition periods also vary with respect to students' math and science experiences pre- and post-transition. Prior to the transition to middle school, students have generally all received the same instruction in math and science and have had no choice in their courses. As a result, they have had no specialized science or math courses. In contrast, both the middle and high school students have had more specialized experiences in science and math. In addition, ability grouping is more common and more salient in these upper grades. High school students in eleventh grade (third year of high school) are more likely to be taking advanced level math or science classes beyond the required courses for the high school diploma (e.g., physics, pre-calculus, calculus).

In this paper, we focus on teachers and their classroom practices pre- and post-transition that might positively affect students' interest and beliefs about math and science. The focus on teachers is warranted because of the authority they hold in the classroom and the unique role they play in informing children about their STEM abilities. Their feedback is critically influential, especially when children encounter a new academic setting. Eccles et al.[4] suggest that one reason for the disruption in math achievement at the transition to middle school is that compared to elementary school teachers, those in junior high and middle school have more negative attitudes toward students and are more likely to believe that academic abilities are not modifiable through instruction. In contrast, teacher support and academic push (i.e., encouragement to achieve in math and science) positively affect children's perceptions and attitudes toward math and science.[8,15] For these reasons, we include students' perceptions of teacher support in our research.

Gender differences were given a special focus in this study because they are so well documented in the transition research. Although the gender gap in science and math achievement in K-12 has narrowed, girls often express less confidence in their math ability than boys; and at higher ability levels high school boys still outperform girls.[17] Recommendations for decreasing these disparities include mentoring, hands-on pedagogy, cooperative learning, focusing on societal problems, emphasizing personal mastery instead of competition, using a multidisciplinary approach, and providing role models.[1,18] Many of the recommendations focus on good STEM teaching practices, regardless of whether the activities are designed specifically for girls. The current research project includes student reports of their teachers' use of these more engaging strategies and examines their potential to offset the expected declines in interest and ability self-perceptions.

Both teacher support and classroom strategies are hypothesized to affect not only achievement in math and science, but also students' self-perceptions of their abilities (e.g., self concept, efficacy, expectations for success) and their interest in math and science. Models of academic achievement and occupation choices [2,4,7] suggest that self-perceptions and expectations for success are the more proximal predictors of academic and career choices. In fact they are better predictors than actual achievement indicators such as math and science grades. Efficacy beliefs are also strong predictors of adaptation and change as well as academic aspirations, level of motivation and resilience.[2] For these reasons, we examine students' self efficacy and interest in math and science as our primary measures of academic outcomes post-transition.

To summarize, the purpose of this study is to describe how student perceptions of science and math teachers' effectiveness, including support and classroom strategies, affect students' academic outcomes related to math and science (efficacy and interest) during three school transition periods. Before addressing this primary goal, we examined the effects of school transitions from elementary to middle school (5th to 6th grade), from middle school to high school (8th to 9th grade) and the last two years in high school (11th to 12th grade) on students' efficacy and interest in math and science. These results provide useful comparative data for earlier research on school transitions. An important contribution of this study is the consideration of both math and science, as most previous research has primarily included only math.

Method

Participants were recruited from fifth, eighth, and eleventh grade classrooms in nine public schools (three each for elementary, middle, and high school). In the last half of the spring semester, schools sent a letter to parents that explained the purpose of the project and asked them to return a consent form to school if they were interested in allowing their child to participate. Parents were told that a $5 donation would be made to their school for each returned consent form and that there was an opportunity for children to participate in a second career survey (not included in this research report) and earn $15 (fifth graders) or $20 (eighth graders and high school students). The initial response rate was 47% of the 1511 potential students with 704 students completing the survey. This included 290 fifth graders, 207 eighth graders, and 207 high school students. 56% of the students were female, 74% were Caucasian (0.8% Hispanic), 22% Black, and the remaining 4% were Asian, mixed race, other, or did not specify a race.

Approximately one year later, schools and students were re-contacted and surveys were re-administered for the post-transition time point. The retention rate was 84% at the second time point (N=595 students). The primary factor affecting retention was that students had moved out of the school district or were absent on the days that the survey was administered.

Procedure and Measures

At each time point, students completed the 172 item *Math, Science, and Technology* (MST) questionnaire in a group setting at their schools during regular school hours. Assent information and directions were read aloud by the research staff and then students were allowed to proceed at their own pace. Research staff were available to answer questions and provide assistance if necessary. Younger children averaged 20 to 30 minutes to complete the questionnaire, and older students were able to finish in 15 to 30 minutes. All questions were answered using 5-point rating scales or multiple choice options.

The MST assessed students' efficacy, interest, classroom experiences, attitudes, goals, and sex stereotypes in the areas of math, science, and technology. We report on three sets of measures from this battery that focus on math and science. Items on the scales were taken from previously published measures. Some items were edited slightly to increase clarity for the younger children in the study and/or make the response format consistent with a 5-point scale. It should be noted that sample sizes vary slightly for different measures due to some participants not fully completing the questionnaire.

Math and Science Self-Efficacy. Two separate measures were created at each time point, one for each subject area (four all together). Questions were adapted from the Michigan Study of Adolescent and Adult Life Transitions (MSALT)[14] and included items related to performance in school (e.g., self-ranking of ability and performance in math and science in comparison to other subjects) and items related to the ability to learn math or science. Items were averaged so that scores ranged from 1 (low) to 5 (high). Internal consistency (a measure of reliability) for these scales was high, with mean *alpha* = .72.

Math and Science Interest. Two separate measures were created for math and science, one for each time point (four scales all together). Items were adapted from the MSALT.[14] The scales combined items related to attitudes (liking, interest in taking more math or science) and the perceived importance and usefulness of math or science for the future. Items were averaged so that Interest scores ranged from 1 (low) to 5 (high). These scales had high internal consistency, with mean *alpha* = .73.

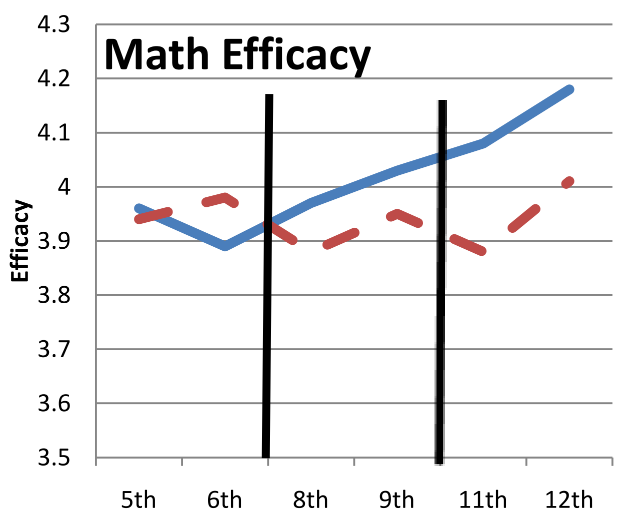
Student Perceptions of Effective Teaching. Two separate scales were created for each time point, one for science and one for math (four scales all together). Items on the scales included assessments of teacher support or "push" (e.g., teacher expectations for students to work hard, teacher encouragement in math and science) and teacher-student relations (e.g., teacher cares how students feel) adapted from Midgley et al.[15] and Wilkins and Ma.[22] Student experience with different classroom activities associated with greater learning and interest in science and math were also assessed (e.g., use of hands-on activities, use of real work examples, including information on careers). These items were averaged to form Effective Teaching scales for math and science such that 1=low Effective Teaching and 5= high Effective Teaching. Internal consistency for these scales was high, with mean *alpha* = .88.

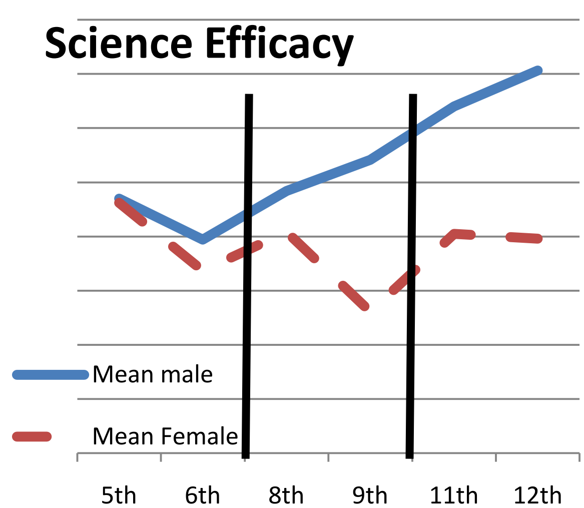
Results

We first examined grade related changes in Efficacy and Interest in math and science to assess how our sample compared with previously reported changes in these constructs over school transitions. Next we examined the impact of Effective Teaching on concurrent and future levels of Efficacy and Interest in math and science.

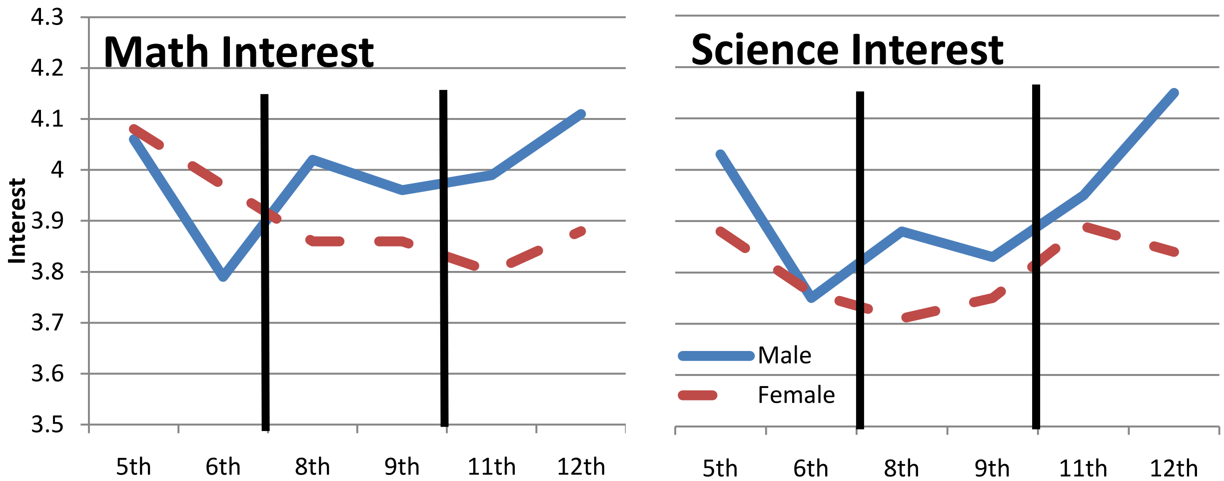
Grade Related Changes in Efficacy and Interest

Two repeated measures MANOVAs were conducted, one each for Efficacy and Interest.[a] The MANOVA's tested if Gender, Starting grade (5th, 8th, or 11th) Transition (before or after transition to the next grade), and Subject (math or science) affected students' Efficacy and Interest scores. (For ease of reading, details of these statistical analyses are presented in the endnotes with the matching superscript.) The results for Efficacy indicated a significant overall difference between girls and boys, but these differences were moderated by Transition and Subject.[b] The graphs below plot the mean Efficacy scores for males and females at each grade for each subject area. Note that black bars separate 6th to 8th and 9th to 11th grades because no data were collected for the intermediating grades. The connecting lines between these data points are hypothetical. As the graphs below indicate, boys generally rated themselves higher than girls for both science and math. However, a richer interpretation of this overall difference is evident when Subject and Transition are considered. First, gender differences in Efficacy appeared to increase over grade level transitions, with very small differences in 5th and 6th grade compared to 12th grade. In addition, there are somewhat different patterns for girls depending on the subject area. For math, over each of the school transitions (i.e., 5th to 6th; 8th to 9th; 11th to 12th) the average math Efficacy score for girls stayed relatively stable between 3.9 and 4. In contrast, for science girls showed decreases in Efficacy from 5th to 6th and from 8th to 9th, but a leveling off in the last two years in high school. Boys, on the other hand, expressed an increasing sense of efficacy in both math and science from 8th grade on through high school.





The analysis for math and science Interest yielded several significant findings.[c] Results are depicted in the graphs below which plot the mean Interest levels for males and females at each grade level for each subject area. Pre-transition Interest was generally higher than post-transition Interest, but the degree of this difference was not the same at each grade level: There were relatively large decreases in math and science interest during the middle school transition (5th to 6th grade), very little change over the transition to high school (8th to 9th), and a slight increase in interest during the last two years in high school. Furthermore, although boys showed greater Interest than girls in both math and science on average, these differences were quite small in the early grades, and increased over time. Finally, math Interest was overall greater than science Interest.



Summary. Changes in Efficacy and Interest over the school transitions partially replicated previously reported findings.[5,16] Similar to previous research, declines were evident in most of these measures during the transition from elementary school to middle school. Boys showed greater Interest and Efficacy in math and science compared to girls, which also replicates previous research. However, math and science did not necessarily follow the same developmental trends for boys and girls. For boys, math and science Efficacy followed very similar paths across the different grades and transitions, generally increasing from 8th grade on. For girls, however, math Efficacy was fairly stable across grades and transitions, in contrast to science Efficacy which generally declined from 5th to 9th grade and increased during the latter half of high school, perhaps because math and science courses are more likely to be elective courses at that point in high school. The findings for math Interest showed a more sustained decline for girls compared to boys from 5th grade on. Science interest fell off considerably for both boys and girls after each transition, except for boys during the last half of high school. Thus, for both math and science, boys showed increases in Efficacy and Interest during the latter half of high school, compared to girls who showed little change over the same time period. In contrast, during the transition to middle school girls and boys generally showed very similar patterns of decline.

The Influence of Effective Teaching on Student Interest and Efficacy

To examine the influence of Effective Teaching on student Interest and Efficacy, correlations were calculated between these measures. Significant positive correlations (r) would suggest that Effective Teaching was associated with Interest and Efficacy. The pattern of correlations was the same for each grade level and gender so the correlations reported in the table below combine grades and gender. Results indicated that Interest and Efficacy in science and math were moderately to strongly correlated with students' perceptions of their teachers' effectiveness. It is noteworthy that Effective Teaching was positively related to Efficacy and Interest concurrently (r = .30 to .47) and over the transition period (r =.21 to .27). This suggests that students' math and science Efficacy and Interest might be affected by their cumulative experiences with teachers.

Correlations: Effective Teaching with Efficacy and Interest

Math				**Science**			
Measure	Transition Time Point⌘	Effective Teaching		Measure	Transition Time Point	Effective Teaching	
		Pre	Post			Pre	Post
Math Efficacy	Pre	.39 (695)		Science Efficacy	Pre	.30 (693)	
	Post	.21 (576)	.36 (568)		Post	.21 (572)	.41 (565)
Math Interest	Pre	.45 (699)		Science Interest	Pre	.34 (698)	
	Post	.27 (580)	.40 (573)		Post	.25 (578)	.47 (570)

Note: All correlations are significant at $p < .001$. Numbers in parentheses are the sample size for each correlation. Numbers vary slightly due to incomplete data for a few cases. ⌘Pre-transition time point includes students in 5th, 8th, and 11th grades; post-transition time point represents the same students when they are in 6th, 9th, and 12th grades.

The next set of analyses examined if *changes* in Efficacy and Interest over the transition periods could at least be partially explained by *changes* in students' classroom experiences with teachers. A series of regression analyses were conducted for each of the four post-transition student measures (Efficacy and Interest for math and science). Each step of the regression equations tested the degree to which different measures were predictive of Efficacy and Interest.

	Step 1	Step 2	Step 3	
Efficacy-post =	(Gender + Efficacy- pre)	+ (Effective teaching-pre)	+ (Effective teaching-post)	+ error
Interest-post =	(Gender + Interest- pre)	+ (Effective teaching-pre)	+ (Effective teaching-post)	+ error

The first step of the regression entered gender and the pre-transition measure for either Efficacy or Interest. By entering in the pre-transition Efficacy or Interest score in the first step of the regression, any subsequent significant effects (R^2 change) for Effective Teaching can be interpreted as being due to its ability to predict *changes* in Efficacy or Interest over the transition. Consequently, the second step tested how well the *pre*-transition Effective Teaching scores accounted for change and the third step tested how well the post-transition Effective Teaching scores accounted for change. Generally, R^2 change ($R^2\Delta$) statistics are interpreted as how well variability in individual students' post-Efficacy or post-Interest are accounted for (or explained by) the measures in each step of the equation. The final β associated with each measure in the equation indicates that variable's contribution to predicting Efficacy or Interest relative to the other variables in all steps of the equation. The full equation R^2 indicates how well all of variables in the three steps combined predict Efficacy or Interest.

The table below shows the results for math and science Efficacy. Not surprisingly, the first step of the regression equation indicated that the pre-transition Efficacy scores were strongly associated with post-transition Efficacy. The significant effect for gender in the science Efficacy equation indicated that boys generally had higher Efficacy scores than girls and is consistent with the results reported previously. Importantly, for both subject areas, *changes* in Efficacy were strongly predicted by Effective Teaching post-transition (step 3).

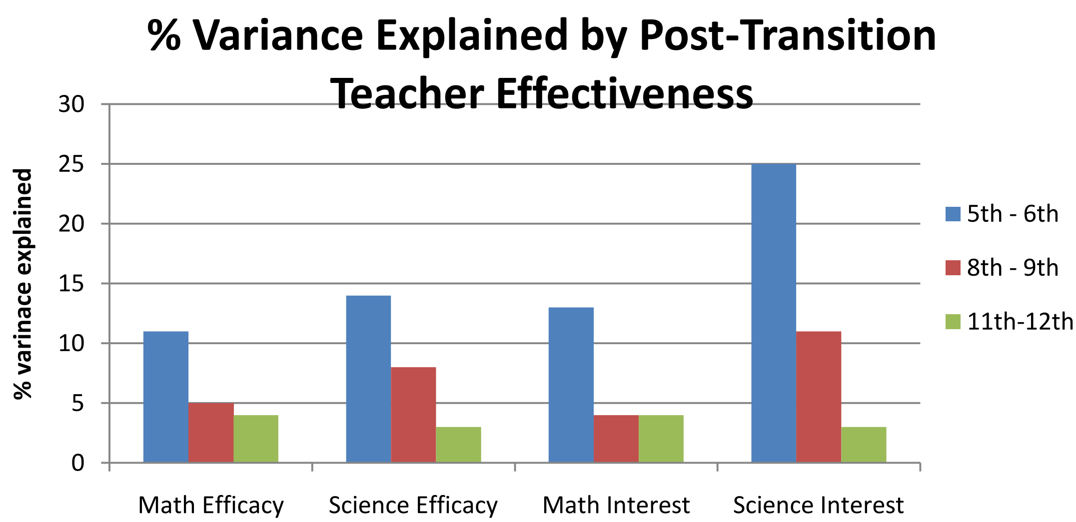
Regressions Predicting Change in Student Efficacy

Step	Variables Entered	Math		Science	
		Final β	$R^2\Delta$ (for each step)	Final β	$R^2\Delta$ (for each step)
1	Gender	.00		-.11**	
	Efficacy Pre-transition	.55***	.34***	.37***	.21***
2	Effective Teaching-Pre-transition	.06	.00	.02	.01
3	Effective Teaching-Post-transition	.28***	.07***	.31***	.09***
Full Equation		$F(4,556) = 94.97$*** $R^2 = .40$		$F(4,552) = 59.69$*** $R^2 = .30$	
** $p < .01$; *** $p < .001$					

The next set of regressions examined student Interest in math and science. (See Table below.). The findings were very similar to those for Efficacy. The significant effects on the first step indicated that pre-transition Interest scores were significant predictors of post-transition scores. Results for step two showed that pre-transition Effective Teaching ratings were not strong predictors of change in interest once the post transition teacher scores were entered (non-significant Final β). On the third step the significant effects indicated that post-transition Effective Teaching was a significant predictor of change in student Interest.

Regressions Predicting Change in Student Interest					
		Math		Science	
Step	Variables Entered	Final β	$R^2\Delta$	Final β	$R^2\Delta$
1	Gender Efficacy Pre-transition	.01 .44***	 .26***	-.04 .35***	 .18***
2	Effective Teaching-Pre-transition	.02	.01*	.004	.01
3	Effective Teaching-Post-transition	.29***	.08***	.39***	.14***
Full Equation		$F(4,562) = 73.33$*** $R^2 = .34$		$F(4,559) = 69.33$*** $R^2 = .33$	
* $p < .05$; ** $p < .01$; *** $p < .001$					

Additional analyses explored the similarity of findings across the three transitions periods (i.e., 5th to 6th, 8th to 9th, and11th to 12th). The analyses above were repeated for the different transition periods and the pattern of results was generally the same. However, the significance of the post-transition Effective Teaching scores ($R^2\Delta$ step 3) appeared to decrease as students got older. The graph below compares the percent of variance explained ($R^2\Delta$ step 3) for each of the transition periods for each measure. It is especially striking that Effective Teaching explained nearly 25% of the variability in 6th graders' interest in science, compared to only 3% for 12th graders.



Summary. This series of analyses consistently found that Efficacy and Interest in math and science were related to students' reports of their classroom experiences. Importantly, changes in Efficacy and Interest over the transition periods could be partially accounted for by post-transition Effective Teaching ratings. An interesting observation is that this relationship was stronger during the transition to middle school compared to the other transition time points. Furthermore, post-transition Interest in science was especially affected by Effective Teaching, notably explaining up to 25% of the variability in the change from 5th to 6th grade.

Conclusions

The main goal of this study was to examine how teacher support and engaging classroom strategies affected students' math and science attitudes and efficacy during key educational transitions. Similar to previous research, we found that negative changes in student attitudes and efficacy were most consistently found during the transition to middle school. Gender differences were more apparent after students reached high school. From 9th grade on, boys' interest and efficacy in math and science showed a steady increase; whereas girls showed small increases for math in the later high school years, but a leveling off for science. Regardless of gender or grade, however, changes for the better in Efficacy and Interest were associated with more effective teaching.

Although it might be expected that students who perceive their teachers as being more concerned about their well being and achievement should have better science and math outcomes, this is one of the few studies to show this relationship for such a wide range of grades and over the transition to middle school and high school. The findings are consistent with Eccles'[4] stage-environment fit model: When teachers provide a classroom environment that better meets students' social, emotional, and educational needs, students can be expected to do better. The findings for the percent of variance explained by the Effective Teaching measure suggest that younger students are more affected by teaching practices than high school students. One reason for this finding might be that in the upper grades students have more choices for math and science courses and may be more likely to choose classes for which they have a strong interest and higher performance expectations. In addition, the change in school environment might be more dramatic during the transition to middle school in comparison to the transition to high school. For example, students transitioning to high school have already adapted to having different teachers for each subject, whereas students transitioning to middle school encounter this for the first time. Thus, effective teaching might play a greater role in the younger years.

Educational Implications

Eccles' *stage-environment fit* theory provides some guidance for the applications of this research for educators who wish to promote math and science education and careers, such as engineering, that require a strong STEM background. First, our findings suggest that both boys and girls making the transition from elementary to middle school need special attention to maintain and promote an interest in math and science. As noted earlier, there is a plethora of ideas for how to make science and math instruction more relevant and interesting, including using hands-on approaches, real world engineering examples, and other more interactive approaches. Our findings indicate that students notice such strategies and they are related to sustained or increased interest and efficacy.

After the transition to middle school, girls had lower Efficacy and Interest scores than boys. With the exception of science Interest during the transition to high school, girls' scores were either fairly stable or declined over the high school transition periods while boys' scores tended to improve. Thus, instructional approaches that specifically target girls (e.g., female role models, showing how math and science helps others) might be especially appropriate during the high school years. Sustaining girls' interest and sense of efficacy in math and science is a critical need for keeping engineering and other STEM careers open to them as they enter college.

Finally, teachers may need training on how to improve their relationships with their students. This study along with others[8,15] suggests that when teachers convey to students that they have a personal interest in students' success and set high expectations for performance, students tend to perform better in science and math.

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Endnotes

[a] Two repeated measures MANOVAs were conducted one each for Efficacy and Interest. The statistical design was a multi-level factorial design: 2(Gender) X 3(Starting Grade: 5th, 8th, or 11th) X 2(Transition: before or after) X 2(Subject: math or science).

[b] The results for Efficacy indicated a significant effect for Gender F (1, 556) = 9.90, $p < .002$, partial eta^2 = .02, and a significant effect for the three-way interaction between Transition, Subject, and Gender, F (1, 556) = 5.14, $p < .024$, Wilk's lambda = .991.

[c] There were three significant main effects for Interest: Transition F(1, 568) = 7.97, $p < .005$, Wilks λ = .986; Subject, F(1, 568) = 8.86, $p < .003$, Wilks λ = .985; and Gender F(1, 568) = 5.36, $p < .021$, partial eta^2 =.01. In addition there were two significant interactions: Gender X Grade, F(2, 568) = 2.97, $p < .05$, partial eta^2 = .01; and Transition X Grade F(2, 568) = 6.72, $p < .001$, Wilks λ = .977.