

Investigating Student Achievement in Mathematics: The Effect of an Integrated Agriculture and Mathematics Curriculum

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Abstract

An integrated curriculum allows students the opportunity to understand key concepts through application in a variety of settings (Conroy & Walker, 2000). The purpose of this study is to determine the effect of an integrated course on student achievement in mathematics. A pretest-posttest control group design was used to examine the differences students' math scores between the eighth grade and ninth grade year. The target population for the study was ninth grade math-risk students in "a designated educational region" of Texas during the 2005-06 school year. The sample consisted of math-risk students in ten schools; five traditional schools and five schools using a newly developed integrated course teaching algebra concepts in the context of agriculture. There was no significant difference found between school types on math scores. Students who are not involved in any form of math remediation had smaller gains in their scale score than students who are involved in a remediation program.

Introduction and Theoretical Framework

The No Child Left Behind Act of 2001 requires states to develop and implement a statewide yearly assessment measuring student's progress and understanding of the state curriculum (United States Department of Education, 2003). The Texas Assessment of Knowledge and Skills (TAKS) test is the measurement of student achievement used to determine achievement in Texas. Students are expected to reach proficiency level of achievement in the areas of reading/language arts, mathematics, and science before graduating from high school. Within the state, it is evident that students are struggling to reach levels of proficiency in these areas. In Region 8 of Texas, 68.7% of ninth grade students failed the mathematics TAKS test (Lair & Williams, 2007).

Students who have unsuccessful experiences in high school or fail to obtain a degree find themselves working minimum wage jobs (Trexler & Barrett, 1992). A primary concern for teachers is to ensure that all students have a positive educational experience in order to successfully complete high school. Through an integrated curriculum, teachers can help students have a successful experience in high school. An integrated curriculum allows students the opportunity to understand key educational concepts through application in a variety of settings (Conroy & Walker, 2000).

Agri-science is an example of an integrated curriculum. Agri-science has been defined as science applied through agriculture (Malpiedi, 1989). In an integrated science and agriculture curriculum, students are introduced to both science and agriculture concepts. The integration

allows for students to apply the concepts to real-life settings. Through application, students create a stronger understanding of concepts. Application of content also allows for students to create an understanding of how concepts are beneficial. “The integration of academic principles into agriculture and natural resources can provide the context necessary for student in the 21st century to understand the world they live in” (Balschweid, Thompson, & Cole, 2000, p. 36).

Not only does the agriculture curriculum allow for application of science concepts, it also provides a context for applying mathematic concepts in the classroom and laboratory. Young, Edwards, and Leising (2007) concluded a math-enhanced agricultural power and technology curriculum showed a positive effect on math achievement. Shinn, et al (2004) concluded mathematics achievement could increase through appropriate instructional strategies and “a contextualized curriculum that connects new ideas and skills to students’ past knowledge and experiences” (p. 23).

Region 8 of the Texas Education Agency has implemented a new course called Agricultural Algebraic Extensive Exploration (A²E²). The A²E² is an integrated agriculture and mathematics curriculum that allows students to apply mathematic concepts in an agricultural setting (Derrick, n.d.). According to the Texas Education Agency (2006), in 2003, 68.7% of the eighth grade students in Region 8 did not achieve at a mastery level of performance on the mathematics TAKS test. The A²E² course was implemented in the school year 2003-2004 at three schools and has since grown to thirty-two of the forty eight districts in Region 8. The mathematics TAKS test scores have increased to 81% mastery in 2006 (Texas Education Agency, 2006). Is it a possibility that the A²E² course is the contributing factor allowing for students to have increased test scores?

The A²E² course is designed for ninth grade students who were unsuccessful in mastering the eighth grade TAKS test and are enrolled in Algebra I. A²E² is designed to assist math-risk students who are struggling in understanding concepts by creating the opportunity for the application of algebra concepts to real world settings. Math-risk students are students who have performed below the standard on the preliminary administration (8th grade) of the TAKS math test. The A²E² course creates learning opportunities through a block scheduling that allows for students to spend the first half of the class learning algebra concepts and the second half of the class applying those concepts to real-world, agricultural topics.

The theoretical framework for this study was Kolb’s Experiential Learning Theory (ELT). Kolb defined ELT as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience” (Kolb, 1984, p. 41).

Kolb’s ELT is a four-stage learning cycle that allows for immediate (concrete) experiences to provide basis for observations and reflections by the learner (Kolb & Chapman, 2003). As an educator, ELT is a particularly unique theory because it is able to contribute to a variety of learning styles while creating the opportunity for an application of the curriculum and development of a deeper understanding of how it works. ELT is a continuous cycle that is depicted in Figure 2.1. Each phase of the cycle builds upon the lessons or concepts learned from the previous and allows for a stronger understanding of concepts students are faced with.

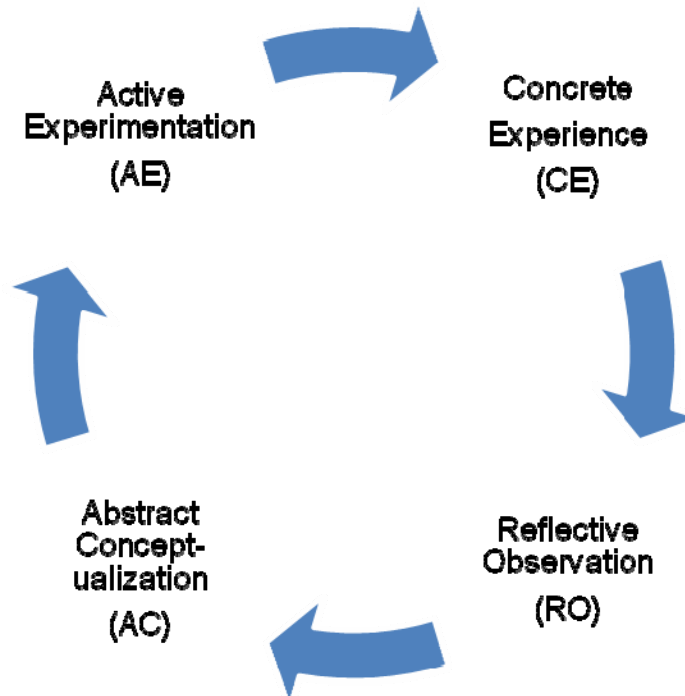


Figure 1: Kolb's Experiential Learning Theory (Kolb & Fry, 1975)

The cycle begins with concrete experience (CE). CE can be a wide range of experiences including, observations, primary text reading, field work, trigger films, examples, and laboratories. CE is followed in the cycle with reflective observation (RO). During RO students begin to reflect on their experience and the effects it has on them personally. Students at this point can achieve this through the use of a journal, log, discussion, or rhetorical questions. After RO students begin applying their newly acquired knowledge in the abstract conceptualization (AC) phase of the cycle. While in this portion of the cycle, students learn how to construct new processes of performing the task at hand. Students attain AC through written papers, model building, projects, or analogies. After AC students move towards active experimentation (AE) and use simulations, case studies, field work, or projects to develop a personal understanding of the methods of how to complete the activity. The AE phase of the cycle leads students back to CE, which allows for questioning and new knowledge to be found (Atherton, 2005).

Driscoll (1994) provided a conceptual framework for distinguishing theories of instruction from theories of learning. Driscoll stated that while the two must be compatible, they represent different views of learning outcomes. According to the model (Figure 1), learning theories attempt to explain the interaction of required learning conditions and outcomes of learning. A foundational assumption is that learning occurs when conditions are ripe. In contrast to learning theories, instructional theories account for “a deliberate arrangement of learning conditions to promote the attainment of some intended goal” (Driscoll, p. 332).

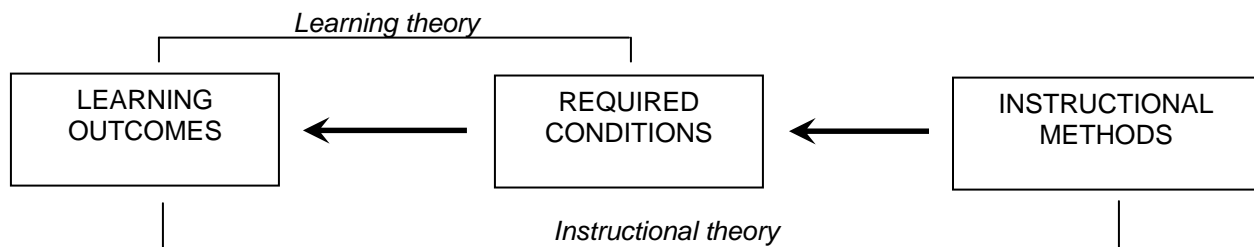


Figure 2. Relationship between Instructional Theory and Learning Theory (adapted from Driscoll, p. 332)

The framework of experiential learning has been used extensively to research agriscience programs at both the high school and university levels of education. Roberts (2006), in a philosophical examination of the experiential learning theory, discussed experiential learning as a process or context in which learning occurs. The process of experiential learning is discussed as cyclical and requires the initiative of the learner to begin the cycle. Roberts also described similarities between experiential learning, problem-solving, and inquiry-based learning.

Inquiry-based learning has been frequently used in science classrooms to increase student achievement and attainment of subject matter (Parr & Edwards, 2004). Their findings determine that the use of a learning cycle, as in experiential learning, can develop the scientific reasoning abilities of students. The learning environment has great effect on student achievement in the classroom. A learning environment conducive to sustained inquiry presents the greatest promise for the improvement of learning (Abraham, 1997). A sustained inquiry classroom is created through the use of a learning cycle approach to teaching such as experiential learning.

While academic educators are being accused of not applying concepts to real-world situations, vocational educators are receiving criticism for having a curriculum that is too specific in training students (Grubb, Davis, Lum, Plihal, & Morgaine, 1991). This problem can be addressed through the integration of academic and vocational curriculums. Researchers have determined that through the integration of curriculums teachers are able to increase students' abilities to think critically, solve problems, and understand concepts. Students are then able to apply those concepts to real-world situations, and increase achievement (Lankard, 1992; Mabie & Baker, 1996). Hoachlander (1999) stated that the prominent way for students to achieve mastery of skills and knowledge is through the application of concepts to real-world situations.

Research has been conducted to find different possibilities to address the issue of low-achieving students in all courses. Low-achieving students are capable of learning much more than what is typically demanded from them (Porter, Archbald, & Tyree, 1991). Researchers have also found that in creating a meaningful understanding for students concerning the curriculum increases motivation of students that results in an increase of student achievement. A meaningful understanding of the curriculum for students can be described as an understanding of the benefits of learning material, applying the material, and knowing the job market helps student develop motivation (Singh, Granville, & Dika, 2002; Porter et al. 1991). Berry (2002) supports

these researchers in saying that students should be able to connect mathematics to their daily lives.

Miller and Gliem (1994) researched the abilities of agricultural science teachers to solve agriculturally related mathematics problems. Their research determined that how students are taught mathematics and problem-solving skills might have a greater influence on student abilities to solve mathematical problems.

Edwards (2004), in a review of literature, found that the development of academic curriculum into vocational courses is one strategy we can use improve student achievement. A²E² is a form of an integrated course in which students study Algebra I concepts in the context of agriculture to increase student achievement and understanding in mathematics.

Purpose and Objectives

The purpose of this study is to determine the effect of an integrated course on student achievement in mathematics. The following objectives were developed to guide the study:

1. Identify the demographic characteristics of math-risk of ninth grade students.
2. Describe math-risk ninth grade students according to their eighth grade and ninth grade mathematics TAKS scale score.
3. Compare math scores of students enrolled in an A²E² course with those not enrolled in an A²E² course.
 - a. H₀: There are no significant differences between A²E² students and traditional students on math TAKS test.
 - b. H₀: There are no significant differences between A²E² students and traditional students on gain score.
4. Explore mathematics TAKS progress by demographic and school characteristics.

Methods and Procedures

The research project was conducted using a causal-comparative research design. In causal-comparative research, the researcher attempts to discover the effect a variable has on given groups or individuals. This type of research is often referred to as *ex post facto* because the treatment has already occurred (Frankel & Wallen, 2006). A pretest-posttest control group design was used to examine the differences students' math scores between the eighth grade and ninth grade year.

The target population for the study was ninth grade math-risk students in Region 17 of Texas during the 2005-06 school year. Five schools incorporated A²E² into their curriculum during 2005-2006 school year. The A²E² treatment group consisted of 9th grade math-risk students in each of those five schools. To form a comparison group, five additional schools were selected. These schools were matched to each of the treatment schools on the characteristics of school size, rural/urban classification, minority enrollment, SES composition, and school classification on standardized testing.

The 2005-06 school year was the most recent year for which standardized math scores were available at the time of the study. From the ten schools selected, data were available for 36 ($n = 36$) students in AE programs and 49 ($n = 49$) students in traditions programs for a total sample size of 85 students ($N = 85$).

Prior to data collection, permission was obtained from superintendents of participating school districts. The lead administrator was asked to provide the most appropriate contact person; in most cases the principal or counselor. The contact person was asked to provide appropriate information for each ninth grade student the met the criteria for math-risk.

For each student, the contact person provided the scale score on the math portion of the state standardized assessment during the 8th grade administration (pretest) as well as the same score on the 9th grade administration (post-test). The contact person reported additional information on each student including enrollment in a math remediation class, gender, ethnicity, and socio economic status.

Data were reported by the contact person on a report form generated by the researcher. A coding system was utilized to allow test scores to be matched with student demographic data and still maintain the confidentiality of the students. Data collected was analyzed using Statistics Package for Social Science (SPSS) 15.0 for Windows.

Findings

Objective 1 sought to identify the demographic information of math-risk students in the ninth grade. The demographic information collected from databases at the school districts yielded the information presented in Table 1. The table presents information of A²E² students, traditional students, and a summary of all students. A slight majority (56%) of A²E² students were female. Conversely, a slight majority (55%) of traditional students were male. Seventy-eight percent of A²E² students were minorities compared to 73% of traditional students. Over 80% of each group qualified for free/reduced lunch program indicating low SES. While A²E² is considered a form of TAKS remediation, just over two thirds of traditional students were reportedly in some form of TAKS remediation.

Table 1
Demographic Characteristics of Math-risk Ninth Grade Students

	<i>A²E²</i> (<i>n</i> = 36)		Traditional (<i>n</i> = 49)		Total (<i>N</i> = 85)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Gender						
Male	16	44.4	27	55.1	43	49.4
Female	20	55.6	22	44.9	42	48.3
Ethnicity						
African American	2	5.6	5	10.2	7	8.0
Hispanic	26	72.2	22	44.9	48	55.2
Native American			9	18.4	9	10.3
White	8	22.2	13	26.5	21	24.1
Free/Reduced Lunch						
Qualify	30	83.3	41	83.7	71	81.6
Not Qualify	6	16.7	8	16.3	14	16.1
Math Remediation						
Yes	36	100.0	35	71.4	71	81.6
No	*		14	28.6	14	16.1

Note. *A²E²* is a form of math remediation.

Objective 2 sought to describe math-risk ninth grade students according to their eighth grade and ninth grade mathematics TAKS scale score. Table 2 displays a summary of the scores on the mathematics TAKS test during the 8th grade and 9th grade administrations. In eighth grade, students had a mean of 1988.61 with a standard deviation of 66.24 on the mathematics TAKS test. Their mean score ($M = 2022.00$, $SD = 105.50$) and standard deviation increased for students on their ninth grade test.

Table 2
Traditional, A²E², and Total Scale Scores on Mathematics TAKS Test

	8 th Grade		9 th Grade	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total (<i>N</i> = 85)	1988.61	66.24	2022.00	105.50
Traditional (<i>n</i> = 49)	2001.00	61.80	2036.20	108.88
<i>A²E²</i> (<i>n</i> = 36)	1971.75	69.16	2002.67	98.91

Students in the A²E² course had a mean score of 1971.75 on the mathematics TAKS test and a standard deviation of 69.16 during their eighth grade year. After being enrolled in the A²E² course, students had a mean score of 2002.67 and a standard deviation of 98.61 for their ninth grade year. Traditional students had a higher mean score ($m = 2001.00$) and a lower standard deviation ($SD = 61.8$) than A²E² students on their eighth grade test. Their ninth grade scores revealed a higher mean score ($m = 2036.20$) as well as a higher standard deviation ($SD = 108.88$) than the A²E² students.

Objective 3 was to examine the difference between students enrolled in A²E² and students not enrolled in A²E² (Table 3). An independent samples *t*-test was used to compare the means of the A²E² students to traditional student on their ninth grade mathematics TAKS test. The findings are expressed in Table 4.3. The research hypothesis for this objective states that students who are enrolled in an A²E² course will score differently on the mathematics TAKS test than students who are not enrolled in an A²E² course ($H_1: x_{A^2E^2} \neq x_{\text{traditional}}$). The null hypothesis states that there is no difference on the mathematics TAKS test between students enrolled in the A²E² course and those not enrolled in the A²E² course ($H_0: x_{A^2E^2} = x_{\text{traditional}}$). The alpha level was set *a priori* at $\alpha = .05$. Traditional students ($n = 49$) scored a mean of 2036.20 ($SD = 108.88$) on the mathematics TAKS test, while students enrolled in an A²E² course ($n = 36$) scored a mean of 2002.67 ($SD = 108.88$). The calculated *t*-value ($t_{83} = 1.46$) was not significant ($p = .15$) at $\alpha = .05$. The null hypothesis was accepted. There was no significant difference between school types on math TAKS.

Table 3

Comparison of Ninth Grade Mathematics TAKS Score by School Type

School Type	Frequency (<i>f</i>)	Mean (<i>M</i>)	Standard Deviation (<i>SD</i>)	<i>t</i>	<i>p</i>
Traditional	49	2036.20	108.88	1.46	.15
A ² E ²	36	2002.67	98.91		

For each group, change scores were calculated to represent the increase in math comprehension from the 8th grade administration to the 9th grade administration (Table 4). In independent samples *t*-test was used to compare the means gain score of A²E² students to traditional students. The research hypothesis states that students who are enrolled in an A²E² course will have a different change in score than students not enrolled in an A²E² course ($H_1: x_{A^2E^2} \neq x_{\text{traditional}}$). The null hypothesis states that students enrolled in A²E² will have the same change in mathematics scale score as students not enrolled in A²E² ($H_0: x_{A^2E^2} = x_{\text{traditional}}$). The alpha level was set *a priori* at $\alpha = .05$. Traditional students ($n = 49$) change in mathematics TAKS scale score was 35.20 ($SD = 95.20$), while students enrolled in an A²E² course ($n = 36$) change in mathematics TAKS scale score was 30.92 ($SD = 95.85$). The calculated *t*-value ($t_{83} = .21$) was not significant ($p = .84$) at $\alpha = .05$. The null hypothesis was accepted. There was no significant difference between school types on change in math TAKS.

Table 4
Comparison of Changed Mathematics TAKS Score by School Type

School Type	Frequency (<i>f</i>)	Mean (<i>M</i>)	Standard Deviation (<i>SD</i>)	<i>t</i>	<i>p</i>
Traditional	49	35.20	95.20	.21	.84
A ² E ²	36	30.92	95.85		

Objective 4 sought to explore mathematics TAKS progress by demographic and school characteristics. Pearson product-moment correlations were used to examine mathematics TAKS scale scores, gender, and socio-economic status. Table 5 reveals the relationships found from the correlation. The relationship between ninth grade mathematics TAKS score and gender had a positive, negligible ($r = .05$) correlation. According to Miller (1994), this eliminates the need for further work attempting to establish causality. Ninth grade mathematics TAKS score and socio-economic status had a negative, low ($r = -.21$) correlation. The coefficient of determination (r^2) was calculated as 4.41%. The coefficient of determination allows the researcher to better describe the amount of variability within the variables. Although gender and socio-economic status have the largest correlation ($r = .31$), they are not significant due to the nature of the variables as they are not free to vary together.

Table 5
Pearson Product-Moment Correlation of Mathematics TAKS Scale Score, Gender, and Socio-Economic Status

	1	2	3
1. 9 th Grade Mathematics TAKS Score	1	.05	-.21*
2. Gender ^a		1	.31*
3. Free/Reduced Lunch ^b			1

Note. ^aGender Coding: 0 = Male; 1 = Female. ^bSocio-Economic Status: 0 = Not Qualify; 1 = Qualify. * $p \leq .05$

Conclusions / Implications / Recommendations

Objective 1 sought to identify the demographic information of “math-risk” students in the ninth grade. The demographic information yielded important information to be considered when designing coursework for math-risk students. Seventy-three percent of the math-risk students were minorities (African American, Hispanic, and Native American). A large majority (81.6%) of the sample have low socio-economic status (SES). It is important to note that 81.6% of the sample is receiving a form of math remediation which will show to be important for students later in the chapter. Gender was shown to not be an indication of a math-risk student. Math-risk students are as likely to be male as female. Further research should focus on variables other than gender as an indication of success on standardized test.

The strong representation of diverse ethnicities in public school systems creates a need for our curriculum and coursework to become culturally diverse. In doing so, students will have opportunities to make real-life connections to concepts. The SES of math-risk students may be an indication of the need to increase funding for this group of students to allow for more teachers and teaching tools for the application of concepts. This is supported by the findings of Lankard, 1992; Mabie & Baker, 1996; & Lee, 1997.

While it is inspiring to see that the majority of students struggling with their education are receiving help and assistance through the use of remediation curriculums and tutorials, it is alarming to see that a percentage of the traditional programs were not providing any form of math remediation. Schools should continue to assist all students in reaching higher levels of achievement. Schools should also further develop programs to help students who are not performing at expectations

Objective 2 was to describe math-risk ninth grade students according to their eighth grade and ninth grade mathematics TAKS scale score. Students enrolled in A²E² are not achieving to the extent of those enrolled in traditional programs. However, even though students in A²E² were lower achieving, their scores changed similarly to those who were not in A²E². This indicates A²E² is as effective as other forms of math remediation in increasing student achievement in mathematics.

Students who are not involved in any form of math remediation had smaller gains in their scale score than students who are involved in a remediation program. This supports the conclusions for Objective 1 that remediation needs to be provided for all students.

Objective 3 was to examine the difference between students enrolled in A²E² and students not enrolled in A²E². The researcher investigated the students' ninth grade mathematics TAKS scale scores and the change in scores from eighth grade to ninth grade. According to the independent samples *t*-test, there are no significant differences between A²E² and non-A²E² on the ninth grade mathematics TAKS test. Change in scores from eighth to ninth grade were also investigated and no significant difference was found as well.

It is plausible the lack of difference in the ninth grade scores and the change in scores is a result of other forms of math remediation. It was indicated that seventy-one percent of non-A²E² students receive a form of math remediation. This supports the conclusions of Objective 2 determining that A²E² is as effective as other forms of math remediation.

Objective 4 sought to explore mathematics TAKS progress by demographic and school characteristics. It was determined that SES explained 4.41% ($r = -.21$) of the variability of students' mathematics TAKS score. The negative direction of the correlation, a function of coding, indicates that as students qualified for the free/reduced lunch program, their TAKS scores decreased. This relationship may highlight an area in which improvements can be made to our current efforts to promote academic achievement. Furthermore, this also indicates there are many other variables making an impact on students' mathematics TAKS scores.

Further researcher should be conducted investigating the cultural bias in our existing curriculum and testing. The findings from this study suggest that minority students have a more difficult experience finding success in mathematics. Existing curriculum should celebrate diversity by implementing interest approaches or activities that represent a wide variety of cultures, allowing students to become more engaged with the material. Further, investigation should be conducted towards teacher diversity and the approach taken to teach concepts in the curriculum. It is a possibility that the method chosen by the teacher is building a barrier and a lack of interest from the students due to presentation of materials or the interest approach.

Research projects should be developed to investigate other forms of math remediation and their effect on student's achievement regarding the mathematics TAKS test. This research project investigated a single type of math remediation. Schools using other forms of math remediation had similar effects on student achievement. In investigating these other forms of math remediation answers could be found to expand the A²E² course to become significantly different and significantly effective as a form of math remediation.

A²E² needs to be explored to determine how it can be expanded to make a greater impact on student achievement. It is the belief of the researcher that the course is effective when there is an opportunity to fully develop lesson plans and activities that allow for students to apply concepts learned in the classroom. The exploration of A²E² could be achieved through replicating this study and expanding it to include a qualitative research aspect as well as a larger population.

A qualitative study should also investigate the amount of time spent preparing for the course by the teachers. This qualitative aspect could allow for an interview of the students. This would create the opportunity to determine what students are learning that is not measured by the mathematics TAKS test. Students could have the opportunity to voice their opinions of the A²E² course and how it could be expanded.

Further research should be conducted investigating other variable impacting math performance. Research project could be conducted investigating a number of different variables that could play a role in helping students increase their scores. An example of a variable that could have an affect on student success is class size. Smaller schools typically have smaller classroom sizes due to the lack of students. Smaller classrooms may allow for students to gain more one-on-one time with teachers allowing for immediate guidance as needed.

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