Investigating the Relationship between Science Self-efficacy Beliefs, Gender, and Academic Achievement, among High School Students in Kenya

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Abstract
The aim of this study was to explore the relationships between science self-efficacy, gender, and academic achievement in genetics among form four (12th grade) students in Kenya and to investiPSTe gender differences in science self-efficacy and academic achievement in genetics. A total of 2,139 students responded to a science self-efficacy questionnaire, adopted from SEMLI-S by Gregory Thomas, David Anderson, and Samson Nashon (2007). A (PST) was then administered to test the academic achievement of students. Data were analysed both descriptively (means and standard deviations) and inferentially (MANOVA and Pearson's Correlations). Results of the analyses revealed that students' science self-efficacy is highly correlated to academic achievement. One-way MANOVA results indicated gender differences in both self efficacy and academic achievement, with female students performing better than male students in both outcome variables. These findings are inconsistent with the extensive research done on gender differences where females always perform poorer than males in science-related courses and tasks and hence have pertinent implications for both biology teachers and science educators.
Keywords: Self-efficacy, Academic Achievement, Gender, Genetics

1. Introduction
Long standing research has shown that males receive higher grades in science classes (Dietz, Felder, Hamrin, & Mauney, 1995) and perform significantly higher on science achievement tests (Government of Alberta, 2004) than their female counterparts. It has been shown that males appear to receive more social support in the classroom and at home. Males are given more attention than females in science classrooms (She, 2001). Research shows that women have been underrepresented in the fields of science, technology, engineering and mathematics (Schiebinger, 2001; Corbett, Hill & Rose, 2008; Leder, Rowley & Brew, 1999; Taylor, Leder, Pollard & Atkins, 1996). Many factors, both biological and social have been attributed to this under-representation (Schiebinger, 2001). According to Zeldin and Pajares, (2000) confidence and self-efficacy are key factors impacting whether women enter into or remain in STEM programs and careers. Other factors include a lack of teacher support (She, 2001), lack of parental support (Tenenbaum & Leaper, 2003), poor motivation (Collis & Williams, 2001), lack of hands-on experience (Shin & McGee, 2002), and poor prior knowledge (Desouza & Czemiak, 2002). Even parents believe that science is less interesting and more difficult for their daughters than for their sons (Tenenbaum & Leaper, 2003).

"A loss of self-confidence rather than any differences in abilities may be what produces the first leak in the female science pipeline" (Alper, 1993, p. 410). Confidence is strongly correlated to which students continue in Mathematics and Science courses and which do not (Jewett,1996). It is thought that self-efficacy may explain course selection patterns in schools that eventually lead to the under representation of women in science (Andrew,1998). Regardless of gender, more career options, including potentially higher career aspirations, are considered by those students who possess a high degree of self-efficacy (Bandura, 1986; DeBacker, & Nelson,1999). If a female believes she is unable to succeed in Science, this altered perception may then subsequently manifest itself in lower grades or in avoidance of Science courses altogether.

The purpose of this study was to investigate the relationship between science self-efficacy, gender and academic achievement among high school students in Kenya. Academic achievement is operationalised as a problem solving test in Genetics. Genetics is a topic in biology that intensively involves problem solving. It was believed these students would have moderate to high levels of self efficacy for genetics; since students self-selected themselves into biology. However, I expected that students with higher self-efficacy levels would earn higher grade in Problem solving test (PST) than students with lower self-efficacy. Hence the need to investigate this expectation. Knowing the relationship between students' self-efficacy and achievement with gender will help high school teachers to guide their students to select science-related careers at college. Many studies have been conducted on self-efficacy and academic achievement but adequate research has not yet established a firm connection between self-efficacy and high school science performance.

2. Self-efficacy
Self-efficacy refers to student's beliefs in their ability to master new skills and tasks, often in a specific academic domain (Pajares and Miller, 1994, cited by Nasiriyan, Azar, Noruzy, Dalvand, 2011). In other words, perceived

self efficacy is concerned with people beliefs in their capabilities to produce given attainments (Bandura, 1997, cited by Bandura, 2006).Self efficacy is explained in the theoretical framework of social cognitive theory by Bandura (1986, 1997, cited by Mahyuddin, Elias, Loh, Muhamad, Noordin & Abdullah, 2006) which stated that human achievement depends on interactions between one's behaviours, personal factors and environmental conditions. Learners obtain information to appraise their self-efficacy from their actual performances, their vicarious experiences, the persuasions they receive from others, and their physiological reactions. Self-efficacy beliefs influence task choice, effort, persistence, resilience, and achievement (Bandura, 1997; Schunk, 1996). Compared with students who doubt their learning capabilities, those who feel efficacious for learning or performing a task participate development of academic self-efficacy more readily, work harder, persist longer when they encounter difficulties, and achieve at a higher level (Schunk, & Pajares, 2002).

2.1 Self-efficacy and gender
Female students tend to underestimate their abilities in Science (Sadker, & Sadker, 1995).

A host of research (Kinsella,1998; Pintrich, & DeGroot, 1990; Smist, & Owen, 1994; Tippins, 1991) has documented that female students have lower self-efficacy in Science compared to male students. Girls' capabilities are undermined by sex-role stereotypes in many cultures intimating that females are not as able as males, especially in such disciplines as math and science (Bandura, 1986; 1997). Another contributing factor could be the lower level of expectations that parents, teachers, and counselors often hold for girls, which can discourage further study in scientific and technical fields (American Association of University Women Educational Foundation, 1999; Sadker, & Sadker, 1995; Bandura, 1997; Astin, & Sax, 1996).

Confidence is strongly correlated to students continuing in math and science courses (Astin, & Sax,1996; Jewett, 1996). In addition, males display more positive attitudes towards careers in science than females (Smist, Archambault, & Owen,1997). Regardless of gender, more career options, including potentially higher career aspirations, are considered by those possessing a high degree of self-efficacy (Bandura,1986). Self-efficacy can even predict career choice (Kennedy, 1996). Because of this influence, "efficacy beliefs partly shape the courses that lives take" (Bandura, 1997). If females perceive their abilities to be low in math and science, a whole technological sector of highly-esteemed, high-paying careers may become off-limits to them. In two separate studies of high school Math students, (Miller, Greene, Montalvo, Ravindran, & Nichols,1996) found that females had lower perceived ability levels in math than males. Low mathematical self-efficacy and inadequate high school math preparation, both being observed give rise to more often in females than in males, lower female aspirations for future study in scientific and technical fields (Lapan, Boggs, & Morrill, 1989). Math self efficacy is a "critical factor" in career choice (Kennedy, 1996). Students with higher levels of math confidence earn better grades in college and pursue science majors more often (Astin, & Sax, 1996). However, mathematics confidence often declines in college and more so for women than men; but for women who pursue math and science majors, mathematics confidence increases (Astin, & Sax, 1996). In addition to the studies mentioned here, a significant amount of research has found low mathematical self efficacy in females.

2.2 Self-Efficacy and Academic Achievement
Previously, self-efficacy has been studied in relationship to student achievement in school science. Researchers reported findings in science education that support previous studies regarding academic performance and persistence (Britner, 2002, 2008; Britner & Pajares, 2001, 2006; Pajares et al., 2000; Zeldin & Pajares, 2000). Self-efficacy predicts intellectual performance better than skills alone, and it directly influences academic performance through cognition. Self-efficacy also indirectly affects perseverance (Bandura, 1997; Multon, Brown, & Lent, 1991). Although past achievement raises self-efficacy, it is student interpretation of past successes and failures that may be responsible for subsequent success. Self efficacy predicts future achievement better than past performance (Bandura, 1986; Tippins, 1991; Miller, Greene, Montalvo, Ravindran, & Nichols, 1996; Chemers, Hu, & Garcia, 2001; Garcia, Yu, & Coppola, 1993). Self efficacy beliefs also contribute to performance since they influence thought processes, motivation, and behavior (Bandura, 1997). Fluctuations in performance may be explained by fluctuations in self-efficacy. For example, varying beliefs in self-efficacy may alter task outcome, whether it involves two similarly-skilled individuals or the same person in two different situations (Bandura, 1997). Individuals high in self-efficacy attempt challenging tasks more often, persist longer at them, and exert more effort. If there are failures, highly efficacious individuals attribute it to a lack of effort or an adverse environment. When they succeed, they credit their achievement to their abilities.

The perception that their abilities caused the achievement affects the outcome rather than their actual abilities (Bandura, 1986). "Those who regard themselves as inefficacious shy away from difficult tasks, slacken their efforts and give up readily in the face of difficulties, dwell on their personal deficiencies, lower their aspirations, and suffer much anxiety and stress. Such self misgivings undermine performance" (Bandura, 1986, p.395). Conversely, individuals with high self-efficacy persevere despite difficult tasks or challenging odds and often succeed because perseverance usually results in a successful outcome (Bandura, 1986). Numerous studies

(Bandura, 1997; Chemers, Hu, & Garcia, 2001; Garcia, Yu, & Coppola, 1993; Pajares, 1996; Pintrich, & DeGroot, 1990) link self-efficacy to academic achievement. For example, in seventh grade Science and English classes, self-efficacy was positively related to cognitive engagement and academic performance (Tippins, 1991). Self-efficacy, self-regulated learning, and test anxiety also were found to be the best performance predictors (Tippins, 1991). Worth to note is that there is very little research to date on potential gender differences in the problem solving skills of males and females within the domain of science. What little research that has been done is inconclusive as to whether females and males differ in the ways they approach and solve problems. It is important to examine problem solving skills given these skills are necessary for correctly setting up and solving scientific problems.

Considering the relevant literature, this study focuses on the differences between boys and girls in terms of science self-efficacy and academic achievement. Accordingly, the present study aimed at addressing the following research objectives:

1. To determine the relationship between science self-efficacy and academic achievement
2. To examine gender differences in science self efficacy among high school students.
3. To find out if boys and girls differ with respect to academic achievement

The following hypotheses were generated for the purpose of conducting inferential tests:

Ho$_1$: There is no relationship between science self-efficacy and academic achievement

Ho$_2$: There are no gender differences in science self efficacy among high school students

Ho$_3$: Academic achievement among high school students does not differ by gender

3. Materials and Methods

3.1 Research Design

This study adopted a correlational research design. This quantitative study design was deemed appropriate since the purpose of this study was to test for statistical relationships between science self-efficacy, gender and academic achievement. Specifically, the researcher adopted relationship correlational study because they explored the relationships between measures of self-efficacy and genetics test obtained from the same group of students at approximately the same time to gain a better understanding of factors that contribute to a more complex characteristic; in this case; academic achievement.

3.2 Participants

A total of 2,139 high school form four (12th graders) were purposively selected because they were the typical group of students who had been taught genetics, the topic under study. Hence they were the right population for this study. Of these students, 1,070(50.02%) were males and 1,069 (49.98%) were females, based on the current demographics of the schools.

3.3 Instruments

Science Self-Efficacy scale (SSES)

Science Self-Efficacy scale (SSES); a five point Likert scale is a sub-scale of SEMLI-S, an inventory developed by Gregory Thomas, David Anderson, and Samson Nashon (2007) and used in assessing the self-efficacy beliefs of students in science was used to assess 12th grade students' science self-efficacy beliefs. The science self-efficacy sub-scale has 10 items examples of which are: *I am confident of understanding the basic concepts taught in genetics;*

I am confident that I will be successful in this biology course. The SSES explores students' perceptions of their confidence to organize and execute actions that are needed to attain science learning goals generally and genetics specifically in the current study. Internal consistency for the modified scale; Science self-efficacy (SSES) for the current study was α=0.873; above the acceptable levels according to Field (2009).

Genetics Problem Solving Test (GPST)

Academic achievement (ACADEM) was measured using a genetics problem solving test (GPST), an open-ended 18-item test; developed by the researchers. The test was subjected to expert review to determine its face and content validity. Face validity is a very basic form of validity in which you determine if a measure appears (on the face of it) to measure what it is supposed to measure. In other words, does the measure "appear" to measure what it is supposed to measure? It is more of a first step in determining validity. Expert reviewers critically assessed the content of the instrument and rated the items on the following rating scale:

1= *Not relevant, 2 = Relevant, 3 = Highly Relevant.*

Two primary goals of an expert review are to reveal problems with an instrument so that they can be remedied prior to going into the field or to sort items into groups that are more or less likely to exhibit measurement errors. The reviewers were asked to review the items for clarity and completeness in covering most, if not all, areas tested for a genetics topic and related concepts for form four (grade 12) students, as well as to establish face and content validity of the instruments and items. All the items were rated relevant, with the mean rating ranging

from 2 (relevant) to 3 (highly relevant). The overall mean rating was 2.56 on a scale of 1 to 3.

3.4 Data Analysis

Data were analysed both descriptively and inferentially. Descriptive statistics included means and standard deviations while inferential tests were Pearson's correlations to test the relationships among the variables and a One-way MANOVA to test for group differences on a linear combination of the dependent variables.

4. Results

4.1 Statistical Assumptions

Pearson's Correlation Assumptions

Pearson's correlation coefficient requires that data are at interval scale for it to be an accurate measure of the linear relationship between the two variables. This assumption was met because data on self-efficacy beliefs and academic achievement were continuous and measured on interval scale. Another assumption of Pearson's r is that for the sampling distribution to be normally distributed for the test statistic, *r* to be valid. This assumption was tested using P-P plots (appendices B & C) and histograms (appendices A & D). The p-p plot for SSE indicates that data points all fall very close to the "ideal" diagonal line meaning that the variable is normally distributed (Appendix C). The P-P plot for ACADEM (Appendix B) has most points falling on the ideal diagonal lines. Results of both plots were echoed by symmetrical histograms(appendices A & D). The assumption of Normality was thus met.

MANOVA Assumptions

Data should be randomly sampled from the population of interest and measured at interval level. This assumption was met because data for dependent variables and covariate were all measured on interval scale. Multivariate normality in which the dependent variables collectively have multivariate Normality within the groups. This was checked through Box's test which was significant. This meant that the assumption was violated. However, since the sample sizes were almost equal (F=1070, M= 1069), MANOVA test statistics are robust to the violation. Homogeneity of covariance matrices was assessed through univariate normality of the dependent variables and both were normally distributed as depicted by P-P plots and histograms (Appendices A to D).

4.2 Descriptive Statistics

The results of the descriptive analyses demonstrated a range of 8 to 40 on the SSES score (on a possible range of 10 - 50) and a range of 2 – 40 on the ACADEM score (on a possible range of 0 - 40) and no evidence of ceiling or floor effects (*M* = 25.80, *SD* = 8.185 for SSES and *M* = 25.28, *SD* = 8.376for ACADEM). The means and standard deviations by gender and country are reported in Table 1.

Table 1. *Descriptive Statistics*

		SSES		ACADEM	
Gender	*N*	*M*	*SD*	*M*	*SD*
Female	1069	26.18	7.611	26.30	7.701
Male	1070	25.43	8.708	24.26	8.888
Total	168	25.80	8.185	25.28	8.376

Further exploration of means gender revealed that females tended to show higher scores on both SSES and ACADEM than male participants.

4.3 Primary Results

Hypothesis 1: There is no relationship between science self-efficacy and academic achievement

Results of the Pearson's Correlation analysis are reported in Table 2.

Table 2: *Correlations between Science Self Efficacy and Academic Achievement*

		Science Self-efficacy	ACADEM
Science Self-efficacy	Pearson Correlation	1	.850**
	p-value		.001
ACADEM	Pearson Correlation	.850**	1
	p-value	.001	

This correlation matrix suggests that there is a significant correlation between science self efficacy beliefs and academic achievement (r = 0.850). Science self-efficacy beliefs of high school students is strongly and positively correlated with academic achievement. Students with high science self-efficacy tend to perform well in academic tasks. In the current study, students who rated themselves as highly confident in genetics registered high scores on the genetics test.

For better interpretation, the coefficient of determination, R^2 was computed as $R^2 = (0.850)^2 = 0.722$. This statistic is a measure of the amount of variability in one variable that is shared by the other. In this study,

the variability in academic achievement by science self-efficacy is 0.722. This means 72.2% of the variability in academic achievement is explained by science self-efficacy beliefs. However, causality is not implied.

Ho2: There are no gender differences of Science Self-efficacy beliefs among high school students
Ho3: Academic Achievement of high school students does not differ by gender

The second and third hypotheses were tested using one-way Multivariate Analysis of Variance (MANOVA). When there are two levels of an independent variable, all multivariate test statistics are equal to each other; therefore, Wilks' Lambda was chosen in order to test the significance.

Box's M Test was significant ($p < 0.001$), hence assumption of homogeneity of variance-covariance matrices was violated. As this test is very sensitive, it is most critical when sample size is small and unequal. In the current study, it is not much of a problem because of equal cell sizes and large N. Results of the MANOVA are reported in Table 3.

Table 3. *Results of One-Way MANOVA Test*

Source	Multivariate				Univariate					
					SSES			ACADEM		
	F^a	Wilks' Lambda	*p-value*	η^2	F^a	*p-value*	η^2	F^a	*p-value*	η^2
GEND	16.058	0.985	0.000	0.015	24.992	0.000	0.012	31.987	0.000	0.015

Wilks' Lambda is less than 0.05 by convention, hence there is a statistically significant difference in means by gender (F (2, 2136) = 16.06, $p < 0.01$; Wilks' Lambda = 0.985; partial $\eta^2 = 0.015$), and therefore we have discriminability. Partial eta squared values provide the researcher with an indication of the proportion of variance in the new combined dependent variable that can be accounted for by the factor 'group'. A rule of thumb is that values larger than .14 (or 14%) indicate a large effect. In this study, the effect size was small; approximately 2% of the variance in the linear combination of the DVs was accounted for by gender. Although a small effect, there is however, evidence of a difference in the means. We can see from this table that gender has a statistically significant effect on both academic achievement (F (1,2137) = 31.987, $p < 0.001$, partial $\eta^2 = .015$) and science self-efficacy (F (1,2137) = 24.992, $p < 0.001$, partial $\eta^2 = 0.012$). It is important to note we have to make an alpha correction to account for the two ANOVAs being run, by applying a Bonferroni correction. As such, in this case, we accept statistical significance at $p < .025$ since there are the two univariate ANOVA test statistics

Again, partial eta squared values are reported showing the amount of variance in the dependent variables. For both DVs, magnitude of the difference was small, based on Cohen (1988) guidelines. Gender accounts for approximately 1.5% of the variance in academic achievement and 1.2 % of variance in science self-efficacy. The two groups (males and females) differed on both academic achievement and science self-efficacy.

5. Conclusion

Often secondary science courses seem to emphasize the coverage and acquisition of content, rather than focusing on increasing students' confidence abilities. The genetics problem solving test in this study was explicitly designed to provide students with problem solving experience. It did not focus on gender as an issue, although our data have revealed significant gender differences.

Perception of self-efficacy can affect whether students are willing to try courses or programs that require problem-solving skills. Moreover, this perception, or lack thereof, affects the future use of such skills (Schneider and Pressley, 1989). As Zimmerman and Capillo (2003) argue, "teaching students to use problem-solving strategies does not guarantee their continued use or generalization to similar tasks unless other self-regulation processes and a wide array of motivation beliefs are involved" (p. 252).

In this study, it was found that perception of science self-efficacy was higher among girl students compared to boy students. This is especially important for female students, as confidence is known to affect their participation in STEM areas (Zeldin & Pajares, 2000). This unique finding has some implications for teachers of biology and by extension science. Firstly, teachers should be aware of the differences in self-regulatory learning between the males and the females, and subsequently, plan to address this situation in terms of curriculum restructuring and implementation. Scores on genetics problem solving test also differed by gender with females performing better than males (Females: M = 26.30 and Males: M = 24.26). This is inconsistent with most research that has shown that boys always perform better in sciences than girls (Chipman, Brush & Wilson, 1985; Desouza and Czemiak, 2002, Fennema, 1984; Lee & Burkam, 1996; Linn & Hyde, 1989; Oakes, 1990; Shin and McGee, 2002). These findings have implications to science educators and curriculum developers.

Because of the significant correlations between self-efficacy and achievement in PST, it is highly recommended that science educators and teachers make a deliberate attempt to assess the existing levels of self-efficacy in students at classroom level. If and when lower levels of self-efficacy are identified, then appropriate interventions should be taken to help raise student self-efficacy levels through vicarious learning, metacognitive prompting, self-regulated learning, goal setting, among others.

For further research, it is necessary to consider the following issues:
- An experimental study in which control of extraneous variables such as, background knowledge, attitude, motivation, and past academic achievement can be done.
- Replication of the study in different science disciplines and comparing science and non-science majors are also recommended.

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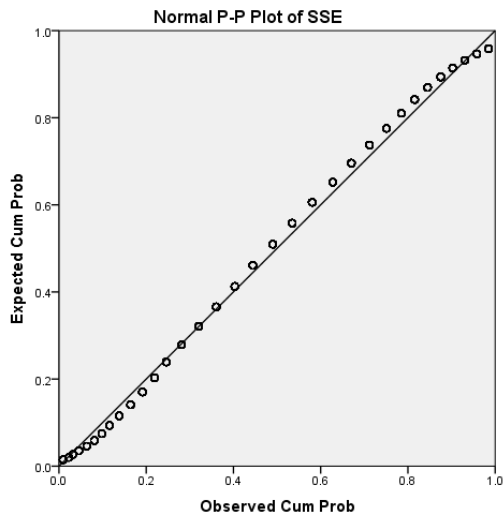
Appendices

Appendix A: Histogram for ACADEM
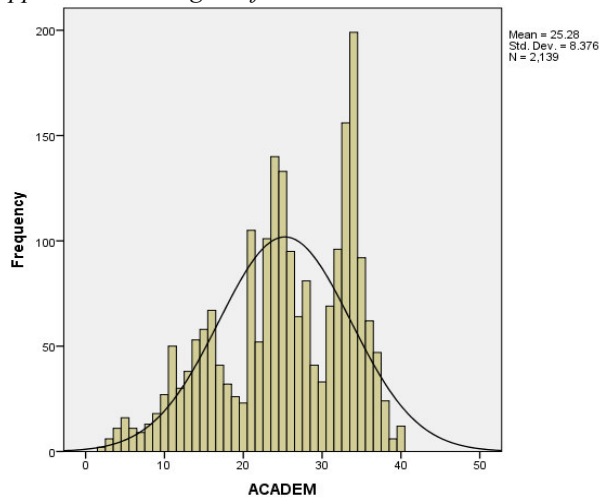
Appendix B. P-P Plot for ACADEM
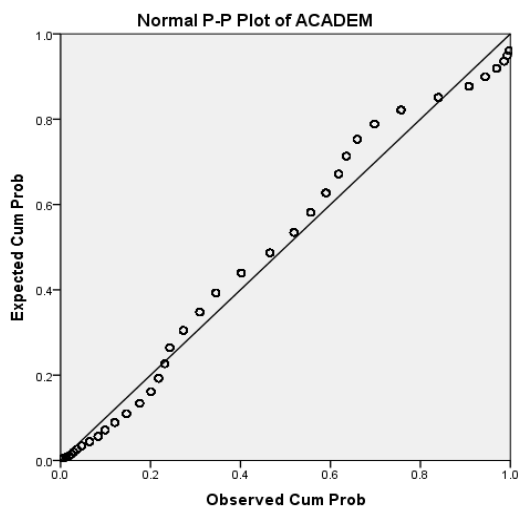
Appendix C. P-P Plot for SSE

Appendix D. Histogram for SSE