Influence of Gender Stereotype on Performance in Science across Gender among Secondary School Students

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ABSTRACT

The purpose of this study was to establish the influence of gender stereotype on performance in science across gender. Fisher's formula was used to sample 175 Form IV students from a population of approximately 1,600 in Migori County, Kenya. Questionnaires, Interview Schedules and Focus Group Discussion Guide were used to collect data. Descriptive statistics, correlation and linear regression were used to analyze quantitative data. Qualitative data was organized into themes and interpreted. Boys had a higher level of performance in science (Mean=39.21, SD=13.33) than girls (Mean=30.51, SD=11.83), and the mean difference was statistically significant at ?=.05 (t=3.99, p=.00, df=172). Girls displayed a higher level of gender stereotype (Mean=1.67) than boys (Mean=1.66), but this difference was not statistically significant (t=-.187, p=.852). Further, gender stereotype significantly correlated with performance in science for both boys and girls; boys had r=-.272 (p=.002, n=125) and girls had r=-.251 (p=.082, n=49), indicating a stronger relationship for male than female students. In conclusion, the impact of Gender Stereotype on Performance in Science was stronger for female students than male students. We recommend that ways of minimizing gender stereotype among secondary school students should be established because it is negatively associated with performance in science. However, such a move should be more intense for female students than male students.

Keywords: Gender, Gender stereotype, Science performance, Kenya.

INTRODUCTION

Weak performance in sciences among girls still creates a big challenge in the field of science (Diane, 2003). Despite the strides made in the last 20 years, female students unlike their male counterparts still shy away from taking physics technical science and Math courses in high school. Consequently, this sees a lower number of female students enrolling for Mathematics and science at the college level. The subject and course selection at the high school level is key determiner in college placement and career choice path (Diane, 2003).

Science, Technology, Mathematics and Engineering (STEM) field has been hit by a great labour shortage challenge as most women fail to enroll for courses in this field. Only 28% of global researchers are women. This percentage however varies from one region to the other (UNESCO, 2016). A greater under representation of women is witnessed in the STEM field. This under representation of women is as a result of several factors including cultural and societal discrimination, school, and labour market marginalization of women (UNESCO, 2016).

Data from the Kenya National Bureau of Statistics (2019) indicate that in general, Kenya has 21,400 female STEM profession and 52,400 male professionals. Only 30 % of university students who take STEM courses are females. This weak representation of females in science is again reflected in the performance of sciences down the ladder. Performance in the Kenya Certificate of Secondary Education (KCSE) examination for instance attests to this worrying trend as boys have outshone girls in all science related subjects from the year 2017 to 2019. Performance in science subjects has not been any better in Migori County as well. Although the average national result for all sciences in the 2018 KCSE stood at an average mark of 27.78% for boys and 24.98% for girls, giving a gender disparity of 2.8% in science performance, female students in Migori County scored 22.63% in sciences while male students scored 26.65% in the same giving a 4.02% gender difference (Migori County Education's Office Records, 2020). This goes against the Millennium Development Goals which advocates for gender parity in STEM performance and promotion of STEM subjects for attainment of Vision 2030.

Although some studies show that males perform better than females in sciences, other studies have indicated no difference in the level of science performance across gender. Other studies have even indicated a better female performance in science than males. One cannot therefore conclusively say that males perform better than females in science or vice versa. It is on this basis of conflicting findings that we sought to establish the gender difference in science performance.

This variation in performance could be possibly explained by the fact that society considers science as a masculine field (Fox et al., 2006; Hill et al., 2010). Students internalize these societal perceptions and define their capabilities based on these parameters. Murphy and Whitelegg (2006) report that female students may choose to drop science courses if the society considers them as masculine even if they have the capability of excelling in them. Society has created barriers for girls in science in terms of negative stereotype beliefs (Belkin, 2008; Hill et al., 2010). As such these gender barriers have seen girls register a weaker performance in science than boys (UNESCO, 2016; Else-Quest et al., 2010; Francis & Skelton, 2005; Hill et al., 2010; FAWE, 2003a; Ayoo, 2002 & Chepchieng & Kiboss, 2004).

Noteworthy is that the fore mentioned studies were either based in the Western countries whose cultural connotation on gender cannot be assumed to be like African values attached to gender. The studies also addressed academic performance in general without paying key attention to differences in performance in science across gender. It is this knowledge gap that we sought to fill. Therefore, the objectives of the study were to:

1. Establish the level of performance in science across gender.
2. Establish the level of gender stereotype across gender.
3. Examine the influence of gender stereotype on performance in science across gender.

METHODOLOGY

Research Design

We used a mixed-methods research design which includes both quantitative and qualitative paradigms. More specifically, we used convergent parallel mixed-methods research design in which quantitative and qualitative data were collected at the same time and analyzed separately.

Sample Size and Sampling Technique

From a population of approximately 1,600 Form Four students in the year 2020 spread out in 240 public secondary schools) who were doing all the 4 science subjects (Mathematics, Biology, Chemistry and Physics), we used Fisher et al. (1991) formula to arrive at a sample size of 175. We then stratified the sample by gender followed by simple random sampling technique to sample the students. Additionally, we randomly sampled 30 heads of science department from the 240 schools.

Research Instruments

We used four tools for data collection; Gender Stereotype Scale (GSS), Science Achievement Test (SAT), Focus Group Discussion Guide and Head of Science Interview Schedule (HOSIS).

Methods of Data Analysis

We used descriptive statistics, correlation analysis and simple linear regression in the analysis of quantitative data. Consequently, we used the Statistical Package for the Social Sciences (Version 24) software for quantitative data analysis. Qualitative data was analyzed thematically.

Ethical Considerations

We observed all the protocols for conducting research in Psychology. This study was approved by the Maseno University Scientific and Ethics Review Committee and the National Commission for Science, Technology, and Innovation (NACOSTI) prior to data collection.

RESULTS

Reliability Analysis

We used Cronbach's alpha to ascertain the degree of reliability for the research instruments. Table 1 shows the values of Cronbach's alpha for each of the tools.

Table 1: Reliability coefficients for tools used in the study

Instrument	Cronbach's alpha	Cronbach's alpha based on standardized items
Science Performance	0.782	0.781
Role Model	0.786	0.787
Gender Stereotype	0.792	0.795

The reliability coefficients were all above the threshold of .70 as suggested by McNeish (2017) who states that a reliability coefficient of above 0.7 is acceptable. Thus, all the instruments were deemed fit and were therefore used for the study.

Level of Performance in Science across Gender

Table 2 shows mean scores and standard deviations (SD) in the various science subjects, and the overall performance in science across gender. Whereas there was no outlier for the male distribution, the female distribution had a single influential outlier (Gender Stereotype=4 and Performance in Science=45). This case was excluded from all analyses in the study.

Overall, performance in science subjects was poor, with males scoring a mean of 39.21 (SD=13.33) and females scoring a mean of 30.51 (SD=11.83). In addition, males outperformed females on the average in each of the subjects.

The best performed subject was Mathematics followed by Biology and then Physics. The worst performance was in Chemistry.

Table 2: Level of performance in science across gender

	Mean Score and (SD) by Gender	
	Male	**Female**
Physics	9.90 (4.36)	6.96 (3.43)
Chemistry	7.39 (3.55)	5.69 (2.52)
Mathematics	11.25 (4.77)	9.02 (4.35)
Biology	10.66 (4.03)	8.84 (3.25)
Overall Mean	**39.21 (13.33)**	**30.51 (11.83)**
Valid N (listwise)	125	49

The highest gender disparity was recorded in physics (Mean difference=2.94) followed by Mathematics (Mean difference=2.23). Biology had the third highest level of gender disparity in performance (Mean difference=1.82) while Chemistry had the lowest gender disparity (Mean difference=1.70).

To determine whether this mean difference in performance in science was statistically significant or not, we used the independent samples t-test at α =.05 (two-tailed). Table 3 displays the result of the analysis which shows that the fundamental assumption for t-test regarding the equality of variances was satisfied at α =.05 (*F*=.92, *p*=.34). With equal variances, the difference in science performance between males and females was statistically significant at α =.05 (*t*=3.99, *p*=.000). Therefore, the mean difference in science performance between males and females was a true difference in the population from which the sample was drawn andnot a result of chance or sampling error.

Table 3: Test of significance for gender difference in science performance

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	**Sig.**	***t***	***df***	**Sig.(2tailed)**
Performance in Science	Equal variances assumed	.92	.34	3.99	172	.000
	Equal variances not assumed			4.21	98.22	.000

Level of Gender Stereotype across Gender

Table 4 displays the means for level of gender stereotype across gender extracted from an independent-samples *t*-test. Males had a mean of 1.90 (SD=.46) while females had a mean of 1.76 (SD=.22). This means that in general, males had higher levels of gender stereotype than females.

Table 4: Gender stereotype across gender

	Gender	*N*	Mean	Std. Deviation
Gender Stereotype	Male	125	1.90	.46
	Female	49	1.76	.22

To determine whether this mean difference in gender stereotype was statistically significant or not, we used the independent samples *t*-test at α = .05 (two-tailed). Table 5 gives the result of the analysis which shows that the fundamental assumption for *t*-test regarding the equality of variances was not satisfied at α = .05 (F =14.07, p=.00). Therefore, as much as the t-test is known to be robust against such a violation, findings on the significance of the difference in gender stereotype between males and females should be interpreted with caution. Further, results showed that the mean difference in level of gender stereotype between males and females was not statistically significant but borderline at α =.05 (t=-1.94, p=.054, df=172), indicating that any difference in level of gender stereotype between males and females was an outcome of chance or sampling error.

Table 5: Test of significance for gender difference in gender stereotype

		Levene's Test for Equality of Variances		***t*-test for Equality of Means**		
		F	**Sig.**	***t***	***df***	**Sig. (2-tail)**
Gender Stereotype	Equal variances assumed	14.07	.00	1.94	172	.054
	Equal variances not assumed			2.56	164.07	.011

Assessment of Linear Regression Assumptions

We used ordinary least squares regression analysis to determine the relationship between gender stereotype and performance in science across gender. This called for checking the assumptions for regression analysis before running the analysis. We checked the following four important assumptions:

1. The distribution of the dependent variable must be normal.
2. The variance of the distribution of the dependent variable should be constant for all values of the independent variable i.e., the assumption of homoscedasticity
3. The relationship between the dependent variable and the independent variable should be linear, and
4. There should be little or no autocorrelation.

Assessment of the above linear regression model assumptions is presented below.

***Test of normality across gender*:** To assess whether performance in science, the dependent variable in this case, violated the normality assumption or not, we plotted normal P-P Plots across gender as presented in Fig. 1. In these graphs, expected cumulative probabilities were plotted against observed cumulative probabilities.

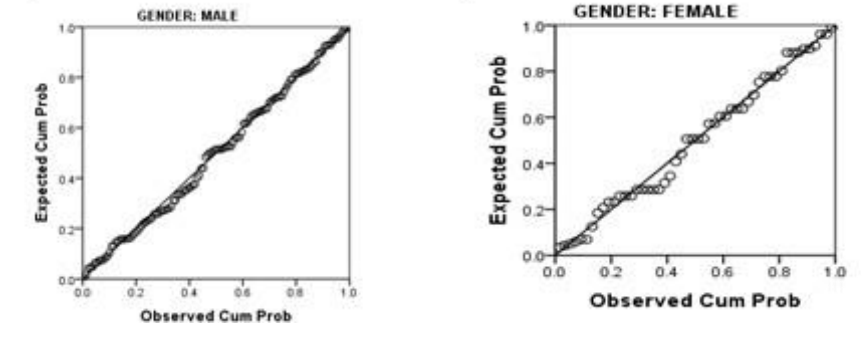

Fig. 1: Normal P-P Plots for performance in science across gender

The points in the scatter plots did not deviate much from the diagonal implying that the assumption of normality was not violated for both males and females.

***Test of homoscedasticity across gender*:** To assess the assumption of homoscedasticity, we plotted the dependent variable (Performance in Science) against regression standardized residuals as shown in Fig. 2. The points were close to the diagonal without displaying a funnel shape. This implied that homoscedasticity was not violated.

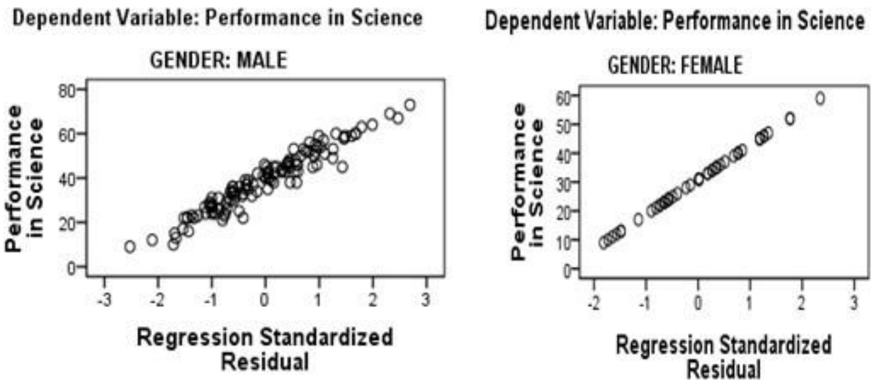

Fig. 2: Scatter plots for assessing violation against homoscedasticity

Test of linearity assumption across gender: We assessed the linearity assumption across gender by using scatter plots, with the dependent variable (Performance in Science) along the ordinate and the predictor (Gender Stereotype) along the abscissa. Whereas there was no outlier for the male distribution, the female distribution had a single influential outlier (Gender Stereotype=4 and Performance in Science=45). As indicated earlier in this paper, this case was excluded from all analyses in the study. The scatter plots after excluding the outlier are presented in Fig. 3.

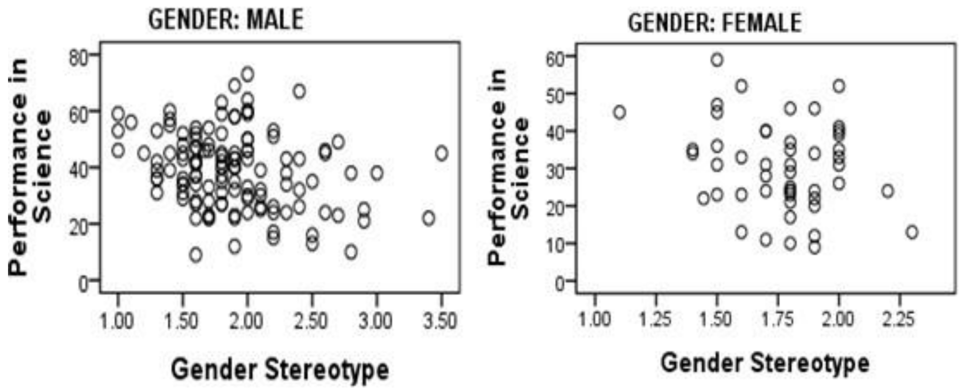

Fig. 3: Scatter plots for assessing linearity assumption

The scatter plots in Fig. 3 indicate that there was a negative linear relationship between performance in science and gender stereotype for both males and females. Thus, the assumption of linearity was not violated.

***Test for autocorrelation across gender*:** Finally, we used the Durbin-Watson statistic to test for autocorrelation. A value for the statistic below 2.0 means there is positive autocorrelation and above 2.0 indicates negative autocorrelation. A rule of thumb is that values in the range of 1.5 to 2.5 suggest little or no autocorrelation (www.analyttica.com, 2021). The value generated in this analysis was 2.00 for males and 1.49 for females. These outcomes were within the normal range required for ordinary least squares regression analysis.

Relationship between Gender Stereotype and Performance in Science across Gender

Subsequent to the above regression diagnostics, and after removing the single outlier in the distribution for girls, we established the correlation between gender stereotype and performance in science for both males and females at α =.05 (2-tailed). The findings are displayed in Table 6. Males had a statistically significant correlation of r = –.272 (p=.002, n=125). However, females had a non-significant correlation of r = -.251 (p =.082, n=49). This implies that when using ordinary least squares regression analysis to predict performance in science from gender stereotype, such a method would provide more accurate results for males than females. This notwithstanding, performance in science increased with decreasing gender stereotype regardless of gender.

Table 6: Correlation between gender stereotype and performance in science across gender

			Gender Stereotype	**Performance in Science**
Males	**Gender Stereotype**	Pearson Correlation	1	-.272**
		Sig. (2-tailed)		.002
		N	125	125
	Performance in Science	Pearson Correlation	-.272**	1
		Sig. (2-tailed)	.002	
		N	125	125
Females	**Gender Stereotype**	Pearson Correlation	1	-.251
		Sig. (2-tailed)		.082
		N	49	49
	Performance in Science	Pearson Correlation	-.251	1
		Sig. (2-tailed)	.082	
		N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

Subsequent to the outcome of correlations in Table 6, we used ordinary least squares regression method to find a linear equation for predicting performance in science for males and females using gender stereotype as the predictor at the 95% confidence interval. The results shown in Table 7 indicate that the linear equation for predicting performance in science for males using gender stereotype as a predictor is Y=54.107-7.859X where Y is Performance in Science and X is Gender Stereotype. Thus, a 1 unit change in Gender Stereotype for males is associated with a decrease of 7.859 units in Performance in Science. Similarly, the equation for females is Y=53.758-13.193X where Y is Performance in Science and X is Gender Stereotype. Thus, a 1 unit change in Gender Stereotype for males is associated with a decrease of 7.859 units in Performance in Science. In a similar fashion, a 1 unit change in Gender Stereotype for females is associated with a decrease of 13.193 units in Performance in Science. Thus, the impact of Gender Stereotype on Performance in Science is stronger among female students than male students.

Table 7: Relationship between Gender Stereotype and Performance in Science across Gender

Males	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	54.107	4.894		11.057	.000

Gender Stereotype for Males	-7.859	2.509	-.272	-3.133	.002
Dependent Variable: Science Score for Males					

Females	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	53.758	13.198		4.073	.000
Gender Stereotype for Females	-13.193	7.431	-.251	-1.776	.082
Dependent Variable: Science Score for Females					

This finding echoes the qualitative finding from the FGD. The respondents' general opinion during the discussions was that the society played a very big role in continuing to promote gender bias in the field of science. The gender stereotype held by society against performance in science among females was a major cause of the problem of poor performance. A story shared by one female respondent gave the deeply rooted barriers erected by society against females' success in science. She reported that:

> *"One day when our family went to visit a family friend, the issue of careers came up. Children were asked their careers of choice and when I said I wished to pursue a career in Civil Engineering, the whole gathering roared with laughter. Condemnation upon condemnation at how that was a totally wrong career choice followed. I was told by my own father that I should stop being over ambitious but when I pointed out that I had been posting good grades in sciences he told me that that was at a very basic level and that the science at the university level was too technical to be handled by girls' brains. The wife to one of his friends told me that sciences are for men and that I should pursue a female career if I wanted to excel in life as a woman. I felt so frustrated and disappointed in myself for having believed I could succeed in science and from that day my performance in science has ever been on a terrible decline."*

After this experience she lost interest in sciences and her performance begun to decline very fast. This same scenario affected most girls as when they reported having interest in pursuing science careers at the university, they were criticized for intending to venture in a male field. The society seemed to glorify male science role models while cast aspersions on prowess of female science role models. Participants reported that the females who had succeeded in science were said to have not done so out of their own effort but from assistance by males around them and so girls were left without genuine role models in science. One female participant reported that:

> *"When I scored an A in Chemistry and became the best in that subject in last year's third term exams, I was accused of befriending our Chemistry teacher and that those were not my marks. My class members challenged me to bring my paper for their verification. However, upon finding no marking errors, they said the teacher had given me the exams plus the marking scheme and so I just collected what I had copied in his house. I felt so painful about this and this affected my performance a lot."*

Generally, all the participants for the discussion agreed that the society has made it difficult for girls to excel in the science field. A statement by one male participant seemed to summarize this problem. He reported that:

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> *"As a woman, nobody, from your teachers, friends, parents and society as a whole believe you can make it in science. Everyone believes you have no capacity to excel in this field and as soon as this thought gets into one's brain, they switch off. From here the performance begins to go down and therefore unless nothing happens this field will forever be dominated by males."*

Performance in Physics has particularly been grossly affected by gender stereotype. Majority of students held very negative gender stereotype beliefs about Physics. One student reported that:

> *"The performance of girls in Physics is so poor. Physics is a male subject and I believe girls should keep off Physics, it is not their field. Why should you go for a subject that you definitely know you cannot excel in? The kind of difficult calculations in Physics cannot be handled by girls and that is why the few pretenders who risk to choose it perform terribly."*

It was surprising that even the female students had the same notion of them not being able to perform as well as their male counterparts in Physics. One female student responded that:

> *"I believe girls cannot compete boys in Physics. Physics is full of boring and difficult stuff that can only be handled by boys. At some point I even regret having chosen this subject because it is turning out to be too technical for me. Again, the thought of being an Engineer scares me. With all the physical work and sweat involved in Engineering, I think it would be so boring, but it's too late to drop it anyway."*

In general, most of the respondents agreed with the notion that performance of female students in science was poorer than male students in Physics. One male participant summed it up by saying that:

> *"Physics has over the decades been presented by society as a male subject and over time this fact has continued to sink in the minds of many, both girls and boys alike. This is what has led to many girls shying away from doing this subject and those who do it in most cases end up performing poorly as they believe they can't do better in it even if they try. I think time has come to reverse this trend and we should find actual reasons why there is this gender disparity so that we solve this problem once and for all."*

DISCUSSION

We found out that in terms of performance in science, male students outperformed their female counterparts. This finding concurs with that of Eriba and Sesugh (2006) in Nigeria which showed that boys have a better performance in integrated science and mathematics than girls. Likewise, the findings echo those of Ochwa-Echel (2011) in Uganda in which girls were found to perform dismally in science subjects in the Uganda Certificate Examinations compared to boys.

The above findings agree with the situation in Kenya where recent literature shows performance in STEM subjects is generally poor for both male and female students. However, female students in Kenya tend to perform worse in comparison with the male students (FAWE, 2003). The same position is held by Wambua (2007) in a study whose findings showed that male students performed better than female students in STEM subjects. With the Science Achievement Test being developed from science questions in the KCSE exams, the study finding mirrors the true performance scenario on the ground as recent national KCSE results of 2017, 2018 and 2019 have all shown that boys continue to perform better than girls in all the science subjects.

The current finding also corroborates other studies done in the local environment. According to the records at the Migori County Office, boys have continued to perform better than girls in the sciences. For instance, in the 2018 KCSE results, Migori County had girls scoring an average mark for all sciences of 22.63% against the boys' 26.65%, giving a gender disparity of 4.02% (Migori County Education Office Records, 2019).

Consequently, the study found that gender stereotype influences the level of performance in science. The current finding echoes those of previous studies by Spelke (2005), Murphy and Whitelegg (2006), Else-Quest et al. (2010), Raviv et al. (2003), Gilbert (2001) and Brickhouse et al. (2000), who found a direct link between negative gender stereotype comments and poor girl performance in science. Such comments were also blamed for the low numbers of girls in science classes as the comments made the girls feel as though science was a 'male field'. Similarly, findings in the present study concur with those of Huguet and Regner (2007), Halpern (2004) and Blicken staff (2005). Previous studies found that gender stereotype threat significantly impacted girls' performance more negatively than boys.

In concurrence with these findings are studies by Wigfield et.al. (2000) and Learch (2003), Onyeizugbo (2003) and Kakonge (2000) who went further to explain how negative gender stereotype beliefs impact on performance in science negatively. The studies opine that socio-cultural factors may influence girls' attitudes toward mathematics and science. For example, parents tend to view Mathematics as more important for sons, and language, arts and social studies as more important for daughters. Thus, parents are more likely to encourage their sons to take advanced high school courses in chemistry, mathematics, and physics and have higher expectations for their success.

CONCLUSION AND RECOMMENDATION

Considering the findings of the study, we conclude that male students in Migori County tend to perform better than female students in all the science subjects. In addition, gender stereotype negatively influences the level of performance in science. The higher the level of gender stereotype, the lower the level of performance in science and vice-versa. It is therefore recommended that there needs to be meaningful intervention by the government and teachers to initiate public awareness campaigns to demystify existing negative stereotype beliefs that depict science as a preserve of the males through motivational talks, public barazas, official media platforms and social media as these beliefs have shown to negatively impact on girls' science performance.

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