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Grit as a Predictor of Chemistry Achievement among Secondary School Students in Kenya

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ABSTRACT: This research was carried out to examine grit as a predictor of chemistry achievement among secondary school students in Kenya. The study was anchored on grit theory developed by Duckworth. The researcher used a correlational research design to establish the relationship between study variables. The target population for the study was 3,320 form three chemistry students in 27 public secondary schools in Etago Sub-County in the year 2023. In this study a sample size of 446 participants were selected from the population using simple random sampling, stratified and purposive sampling. A pilot study involving 30 students from one of the schools within the Sub-County was conducted to refine the reliability and validity of the research instruments. Data were collected using questionnaires and chemistry pro forma forms and then analyzed using the Statistical Package for Social Science (SPSS version 25). The results indicated a significant positive correlation between grit and chemistry achievement, r (433) = .65, p< .05. The study found no statistically significant gender differences in grit in relation to chemistry achievement t (433) = -.39, p = .70. Grit significantly predicted chemistry achievement, F (2,433) = 133.96, p < .05 and its moderation with gender accounted for 5% variance in chemistry achievement. Study recommends that chemistry teachers should enhance effective teaching aids to boost the interest and perseverance (grit) of students during chemistry learning for better achievement in the subject.

I. BACKGROUND TO THE STUDY

Grit has been considered as an important construct for learning and achievement in chemistry. It is defined as the passion and sustained persistence towards the achievement of long-term goals without any attachment for recognition or rewards (Duckworth, 2007). Learners with high level of grit develop strong motivational beliefs in enhancing resilience, ambition and self-control in the pursuit of chemistry concepts using effective strategies (Oluoch, 2018). The improvement of science and technology has a strong correlation with the achievement in chemistry among other science subjects; therefore, a country's development largely depends on its commitment to improve the quality of science education. Quality science education prepares the learners with required skills of finding solutions towards different challenges that face the nation (UNESCO, 2016).

Despite the efforts that have been made to improve the achievement in chemistry, a substantial number of secondary school students in different countries across the world, continue to achieve unsatisfactorily in the subject. In the United States of America (U.S.A), Trends in International Mathematics and Science Study (TIMSS, 2019) reported a dismal achievement in science assessment as compared to other countries like Singapore.

Christopher (2020) established that the level of chemistry achievement in Philippines remained consistently low among university students. The researcher associated this with low level of grit by majority of student taking chemistry hence need for the current study.

Alfred et al. (2023) revealed that there was below average achievement in science subjects in Uganda despite an increased effort by the government to foster the achievement. In Kenya, Malala et al. (2021) study in Bondo Sub-County observed that there is dwindling achievement in chemistry. The research pointed out that inadequate resources and unconducive learning environment were among the factors that contributed to such declining achievement in chemistry.

In Kisii County, there are also concerns about below average achievement in chemistry. Majority of the secondary school students were achieving dismally with many of the students getting low grades in the KCSE examinations (Mochire & Sabellah, 2018). The Examination Report (2022) from Etago Sub-County Office demonstrated that the KCSE mean scores in chemistry for the last five consecutive years (2018 to 2022) were below average. The report further indicated that chemistry was the worst achieved science subject among the three science subjects (Physics, Biology and Chemistry). The negative attitude among learners and inadequate learning resources in chemistry were identified as factors that contributed to such below achievement in Chemistry (Ojukwu, 2016; Oluoch et al., 2018; Malala et al., 2022).

Below average achievement in chemistry has also been associated with the students' grit towards learning chemistry. Grit refers to an inner drive that guides a person towards achieving a goal that an individual cares about so much (Duckworth, 2007). Two subscales of grit exist; interest and perseverance. Students' interest in learning determines the amount of time invested in understanding learning content and the kind of resources mobilized to enhance learning (Krap, 1992).

Perseverance is the ongoing desire to accomplish objectives and enhance abilities in achievements through steadfast efforts (Dweck, 2017).Duckworth et al. (2007) reported that students' interest and perseverance (grit) was directly proportion al to academic achievement. The present study sought to examine the relationship between both domains of grit and chemistry achievement.

The purpose of the study

This study aimed to establish the relationship between grit and chemistry achievement. The research further purposed to examine the predictive power of grit towards the achievement of chemistry among secondary school students in Kenya.

Objectives of the study

i Establish the relationship between grit and chemistry achievement among form three students.

ii To test for gender differences in grit and chemistry achievement among form three students.

iii Determine the prediction equation of chemistry achievement from grit among form three students.

II. LITERATURE REVIEW

Many studies have not paid attention on the relationship between grit and chemistry achievement. Majority of the relevant studies have concentrated on the relationship between grit and academic achievement among learners of different levels. A cross-sectional approach study carried out in Korea to investigate the association between grit and academic achievement among nursing students showed a positive correlation between grit and students' academic success (Mikyoung, 2021).Another study by Usman et al. (2021) examined the relationship between grit and academic achievement. The researcher employed correlational research design to explore the association between the predictor and outcome variables. The results indicated a strong correlation between grit and academic success among learners.

In China, Wang (2020) explored the influence of grit on academic attainment among secondary school students. The findings revealed that grit was significantly related to academic success among learners with high IQs. Edoka et al. (2020) explored the association between grit and parental monitoring on academic success among students in Nigeria. The Multiple regression results indicated that there was a positive significant correlation between grit and academic attainment.

In Kenya, Brigid (2022) investigated the influence of grit on academic achievement among secondary students in Bungoma. The results demonstrated that grit predicted academic achievement among students. Studies on gender differences and grit in relation to chemistry achievement has also been of great concern. Oluyemo et al. (2020) examined the relationship between gender differences and mathematics interest (grit).The study findings showed that male students performed better in mathematics interest (grit) and achievement as compared to female students. Some of the researchers have also explored the prediction of grit on chemistry achievement; the findings revealed that grit significantly predicted academic achievement among learners (Yaure et al., 2021).

III. METHODOLOGY

Target population, sample size and sampling technique

The study targeted 27 public secondary schools in Etago Sub County in Kisii County with 3,320 form three students taking chemistry in the year 2023. This study adopted purposive, simple random, stratified and proportionate sampling techniques in data collection. Schools were selected using Kothari (2021) recommendation of 10% and above while the students sample was obtained using Slovin's (1960) formula;

$n = \frac{N}{1+N(e)^2}$; where N is the target population and e is the margin of error (0.05).

$n = \frac{3,320}{1+3,320(0.05)^2} = 357$

To offset non-response rates, Draugalis et al. (2008), proposed the following sample size adjustment formula "Number of participants to include in original sample" = "Number of people expected to respond" / "Probability of response" = Number of participants to be included in original sample. The desired sample size is "357" and the expected response rate is "80". Therefore, the corrected number of participants is "357 / 0.80 = 446.

Research Instruments

Grit Questionnaire (GQ-12)

The study adopted grit questionnaire that that was used among students of different academic standards developed by Angela Duckworth (2007) with 12 items, α =.72. The questionnaire comprises of 12 items that were measuring grit on a scale with five possible responses ranging from Strongly Disagree to Strongly Agree.

Achievement Pro Forma

To measure the student's chemistry achievement, the researcher examined the achievement records of the form three students using the achievement pro forma.

IV. FINDINGS

The descriptive statistics for Grit by gender are presented in Table 1 below.

Table 1. Descriptive Statistics of Grit by Gender

Gender	*N*	Min	Max	*M*	*SD*	*Sk*	*Kur*
Male	209	25.00	52.00	37.19	3.98	.27	1.28
Female	226	28.00	51.00	37.02	4.61	.45	-.23
Total	435	25.00	52.00	37.11	4.32	.40	.35

Note. N = Sample size; Min = Minimum; Max= Maximum; *M* =Mean; *SD* = Standard deviation; *Sk* =Skewness; *Kur* = Kurtosis

The mean score for male students was 37.19 (*SD* = 3.98), slightly higher than the mean score for female students 37.02 (*SD* = 4.61)). The maximum score for male students was 52, with a minimum score of 25. The maximum and minimum scores for the female students were 51 and 28 respectively. The skewness and kurtosis coefficients indicate that the data was normally distributed. The results further confirmed that male students scored better in grit as compared to the female students. Grit was categorized into three levels and the descriptive statistics scores for each of the levels with respect to chemistry mean score are presented in Table 2.

Table 2. Descriptive Statistics of Grit Levels and Chemistry Mean Score

Gr it Levels	*N*	*M*	*SD*
Low	125	32.31	1.88
Moderate	302	38.76	2.98
High	8	49.63	1.78
Total	435	37.11	4.32

Note. N=Sample size; *M*= Mean score; *SD*= Standard deviation

Grit was measured in three levels namely: Low, Moderate and High. Students with high grit level obtained the highest mean score of 49.63 with a standard deviation of 1.78 on chemistry achievement. Those with moderate grit had a mean of 38.76 with a standard deviation of 2.98, while the students who had low level of grit scored a mean of 32.31 with also a standard deviation of 1.88 in the achievement of chemistry.

The Table 3 gives descriptive statistics of chemistry achievement by gender.

Table 3. Descriptive Statistics of Chemistry achievement by Gender

Gender	*N*	Min	Max	Range	*M*	*SD*	*Sk*	*Kur*
Male	209	34.23	81.08	46.85	50.15	8.22	.54	.37
Female	226	34.23	77.24	43.01	48.05	10.99	.70	-.50
Total	435	34.23	81.08	46.85	49.14	9.79	.75	.03

Note. N = Sample size; Min = Minimum; Max= Maximum; *M* = Mean; *SD* = Standard deviation; *Sk* =Skewness; *Kur* = Kurtosis

Table 3 establishes that the average mark for male respondents was 50.15(*SD* = 8.22) while that of female students was 48.05(*SD* = 10.99).The maximum score for the male students was 81.08 while the minimum score was 34.23. Female students had a minimum and maximum score of 34.23 and 77.24 respectively. This implies that male students had higher score in chemistry as compared to female student.

Hypothesis Testing

To find out the relationship between grit and chemistry achievement among the students, the following null hypothesis was advanced.

$H0_1$: There is no significant relationship between grit and chemistry achievement among secondary students. In order to determine the relationship, the hypothesis was statistically tested using Pearson's product moment correlation coefficients test and the results are presented in Table 4.

Table 4. Correlation between Grit and Chemistry Achievement

	Chemistry score
Grit	.65**
Grit Interest	.82**
Grit Perseverance	.52**

***Note. N* =435**

Table 4. Demonstrates that there was strong positive and significant correlation between grit and chemical achievement r (433) = .65, p < .05. Additionally, the findings revealed that there was a positive significant correlation between the domains of grit and chemistry achievement. For interest; r (433) = .82, p < .05 while for perseverance sub domain; r (433) = .52, p < .05. Based on the results, the null hypothesis was rejected. The findings show that grit plays a crucial role in the achievement of chemistry.

Table 5. Regression model summary for Grit sub domains

Model	*R*	R^2	Adjusted R^2	*SEE*
1	.82[a]	.68	.67	5.59
2	.83[b]	.68	.68	5.53

a. Predictors: (Constant), Grit-Perseverance, Grit-Interest

b. Predictors: (Constant), Grit-Perseverance, Grit-Interest, Gender

The findings in the Table 5 show that perseverance and interest were the predictor variables in model 1.The multiple regression co efficient of interest and perseverance as the predictor variables was 0.82 indicating a strong positive correlation towards chemistry achievement. *R* square was .68 implying that 68% variance in chemistry achievement can determined by both sub domains of grit. In model 2, the influence of gender as a moderator variable was investigated, the regression co efficient was .83 and the *R* square remained .68. To examine if the two levels of grit significantly predicted chemistry achievement, ANOVA was conducted and the results are shown in Table 6.

Table 6. ANOVA Summary for the Sub domains of Grit

1	Regression	28160.15	2	14080.08	450.66	.00[b]
	Residual	13497.04	433	31.24		
	Total	41657.19	435			
2	Regression	28460.11	3	9486.70	309.82	.00[c]
	Residual	13197.09	432	30.62		
	Total	41657.19	435			

Note. *SS* = Sum of Squares; *Df* = Degree of Freedom; *MS* = Mean Squares

a. Dependent Variable: Chemistry T score

b. Predictors: (Constant), Grit Perseverance, Grit Interest

c. Predictors: (Constant), Grit Perseverance, Grit Interest, Gender

The results obtained in model 1, indicates that both perseverance and interest significantly predict the chemistry achievement, *F* (2, 433) = 450.66, *p*<.05. In model 2, the researcher investigated the influence of gender as a moderator variable. The findings further showed a significant prediction of chemistry achievement *F* (3,432) = 309.82, *p*< .05, from interest and perseverance even in the inclusion of gender as a moderator variable. The regression coefficients of the predictor variables are shown in Table 7 given below.

Regression Coefficients for Grit Sub Domains

					T	*P*
		B	*SE*	B		
1	(Constant)	.68	2.49		.27	.00
	X_1	2.52	.16	1.79	15.12	.00
	X_2	.08	.17	.05	.48	.02
2	(Constant)	.12	2.42		.05	.00
	X_1	.79	.53	.24	1.49	.00
	X_2	1.73	.58	1.20	2.98	.00
	X_3	.99	.30	1.12	3.28	.17
	X_4	.94	.33	.96	2.86	.32

Note. Outcome Variable: Chemistry T score ; X_1= Interest; X_2 = Perseverance; ; X_3 = Moderation term between Interest and Gender; X_4 = Moderation term between Perseverance and Gender; B = Unstandardized Coefficients; SE = Standard Error; β = Standardized Coefficients

The model, 1 in the Table 7. Shows that the regression coefficient of interest was 2.52 while that of perseverance was determined as 0.08. The findings indicated that both domains of grit significantly predicts the achievement of chemistry among secondary students. The subscale of interest had a positive significant regression coefficient of β = 2.52, p<.05.This implies that a unit change in the interest of the learners towards chemistry results to 2.52 change in the chemistry achievement. Perseverance had a regression coefficient of β =0.08, p< .05.This similarly shows that a unit change in the perseverance leads to 0.08 change in chemistry achievement.

The prediction equation for the Model 1 was as given below.

$\hat{Y} = 0.68 + 2.52\ X_1 + 0.08\ X_2 + ε$----------1

Where $\hat{Y}$ = Predicted chemistry achievement; X_1= Interest, X_2 = Perseverance, and ε = standard error.

In Model 2, gender was included as the moderator variable. This decreased the predictive value of interest to .79 and increased the predictive value of perseverance to 1.73. The predictive values of the moderator terms were not statistically significant in predicting achievement in chemistry β =0.99, p = .17 and β = 0.94, p = .32 in that order. The regression coefficient prediction equation in model 2, was given as:

$\hat{Y} = 0.12 + 0.79\ X_1 + 1.73\ X_2 + ε$----------2

Where $\hat{Y}$ = Predicted chemistry achievement; X1= Interest, X_2 = Perseverance and ε = standard error.

Using the regression equation from model 2, it was found that a change of one unit in the interest of a student was associated with a change of 0.79 in chemistry achievement; similarly, the unit change in perseverance resulted to a change in the achievement of chemistry by 1.73.

Based on the findings obtained, the null hypothesis was rejected since interest and perseverance significantly predicted achievement in chemistry.

Table 8. Independent Samples T Test for Gender Differences in Grit

		T	*Df*	Sig. (2-tailed)
Grit	Equal variances assumed	-.39	433	.70
	Equal variances not assumed	-.39	431.09	.70

The findings revealed that there were no statistically significant gender differences in learning approaches, t (433) = -.39, p = .70. Therefore, the null hypothesis was retained suggesting that the student grit do not differ substantially on basis of gender towards studying chemistry.

Prediction of Achievement in Chemistry from Learning Approaches

The second objective of the study was to determine the predictive weights of grit in chemistry achievement among the students.

Hypothesis Testing

To determine the predictive weights of grit in chemistry achievement, the following hypothesis was tested.

$H0_2$: Grit significantly do not predict chemistry achievement. The result for the analysis is given in Table 9.

Table 9. Regression Model Summary for the Prediction of Chemistry achievement from Grit

Model	R	R^2	Adjusted R^2	*SEE*	ΔR^2	*F*	Sig.
1	.68[a]	.46	.46	7.40	.46	133.96	.00
2	.72[b]	.52	.51	7.03	.05	18.15	.00

a. Predictors: (Constant), Grit

b. Predictors: (Constant), Grit, Grit Gender

The results in Table 9 shows that in model 1, 46% variance in the prediction of achievement of chemistry can be explained by the level of grit among the students. The findings further indicated that grit had a positive strong correlation with the achievement in chemistry, R = 0.68. Model 2 shows the prediction of achievement in chemistry from the moderator terms between grit and gender. The results revealed that ΔR^2 = 0.05, showing that the moderation between grit and gender accounts for 5% variance in chemistry achievement.

V. DISCUSSION

The current study found that there was a positively and significant relationship between grit and chemistry achievement among students. The results indicate that grit is an important construct towards the achievement of chemistry. The results of the present study corroborate the results of Park (2023) in the study that examined the relationship between grit, self-esteem and academic achievement. The results revealed that grit had a statistically significant positive relationship with academic achievement. Thus, to enhance achievement in chemistry in secondary schools it is necessary to support grit and self-esteem among students.

The findings of the current research also support the theoretical perspective that grit is an important factor that influences students in understanding abstract scientific concepts (Duckworth, 2007). The theory further argues that students' academic success is majorly guided by the interest and perseverance that gives individual students autonomy resulting to high academic achievement particularly in chemistry. Lam and Zhou (2022) study investigated the impact of grit on academic achievement. The results established a significantly stronger association between perseverance and academic achievement.

Other studies have established that grit and academic self-efficacy plays a crucial mediating role in the influence of a growth mindset towards learning (Keli et al., 2023).The findings suggest that students with growth mindset as a result of grit and academic self-efficacy accept failures and then put more effort while monitoring themselves to overcome academic challenges. This translates into academic achievement especially in chemistry among other science subjects.

The findings of the present study are also in agreement with the results of Irine and Aloysius (2023) in the study that explored the predictive effect of grit on academic achievement among students. The findings of the study indicated a significant and positive prediction between grit and academic achievement of the students. The results implies that grit is an important non-academic construct that predicts the academic achievement among students. Therefore, focused intervention is required for improving students' grit and enhancing their science achievement with education program.

Similar results by Marlena et al. (2022) revealed that grit is an independent predictor of academic success among learners. The researcher further argued that students with low level of grit fail to measure academically compared to those with moderate and high level of grit.

A study done in Chinese by Xiayu (2020) on the relationship between gender as a moderator variable, grit and academic achievement contradicted the results of the current study. The results of the reviewed study showed that grit was only significant for male students but not for the female students in relation to academic achievement. The findings of the current study bridge the gap and opens new research opportunities on how the moderation of gender relates with chemistry achievement among secondary school students.

VI. CONCLUSIONS AND RECOMMENDATIONS

The study aimed to investigate the relationship between grit and chemistry achievement among secondary school students. The prediction of grit and the influence of gender as a moderator variable towards the achievement of chemistry were also explored. The results indicated that there was a positive and significant relationship between grit and chemistry achievement. Grit predicted the achievement of chemistry. The study further established that gender of the student had no moderator effect on the relationship between grit and chemistry achievement. The findings suggest that grit is a crucial construct that influences the achievement in chemistry. The findings imply that teachers should carefully plan lessons and use teaching aids, which constitute the interest of students during learning process. Based on the results, the study recommends that chemistry teachers should always implement efficient teaching techniques to boost students' interest and perseverance in learning chemistry.

Declarations

Author contribution statement

Ezra Nyasimi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

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