Correlates gender traits and mindset on the choice of physics subject at high school in Kenya

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ABSTRACT

Higher education and training in science, technology, engineering, and mathematics (STEM) are important for the industrial growth and development of any nation. Physics subject provides the basics for training in many STEM areas. However, failure to pursue physics to the end of high school denies learners opportunities in STEM courses. This research employed a correlational design and survey method to examine the relationship of gender traits (GT) and mindset (MS) with learners' intention to choose physics among 378 high school students randomly sampled. The study adopted the gender traits test and mindset questionnaires. The Chi-square test for the relationship of GT and MS with the intention to choose a physics subject yielded p>0.05. These results revealed that no student is deprived of an opportunity to pursue physics to higher levels on account of their GT or MS. Thus, attempts to increase the number of learners who can potentially pursue STEM courses by studying physics in high school should focus on other known factors other than GT and MS.

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1. INTRODUCTION

Globally, higher education and training in science, technology, engineering, and mathematics (STEM) are vital for the industrial growth and development of any country [1]. Physics, one of the STEM subjects provides the basis for technological advancement, and understanding of energy is a fundamental building block for engineering practices [2]. Further, physics is a vital subject for developing critical thinking skills because students not only learn the theories of a phenomenon but also how such theories are applied in daily life [3].

At high school, learners are required to choose their preferred science subjects while in form two or grade 8 equivalent. This choice determines their career pathways into the STEM education. This implies that the choice of STEM courses takes place while students are in junior secondary way before they join college or university [4]–[6]. The national trends show that only 25% of the learners choose physics with a ratio of 1:2 for female and male [7]–[9] despite the importance of physics as a foundation for future trainings in most STEM courses.

Many studies indicate perceived physics difficulty (PPD) as one of the predictors for selection of physics subject. The difficulty is suggested to arise from course content, teacher issues and students' issues [10]–[15]. The teachers' issues are related to their ability to use various teaching/learning strategies [16]–[22]. Managing the teachers' issues controls for other predictors such as course content [23]; this further overcomes the students' attitude, discipline and motivation to pursue physics [24]. The students' related factors attributed to PPD includes their personal abilities, and views associated with their future aspirations and influence from colleagues [10], [25].

However there are other predictors' of the choice of physics such as learners' enjoyment [26]–[28] and the learners' social economic background. The social economic background determines the exposure of the learners to contemporary issues such as career aspirations, technological advancement, information/advice availed to learners and role models [18]. This determines the physics content exposure to the learner and has implications on PPD [23].

This paper examined the relationship between gender traits (GT) and mindset (MS) with the intention to choose physics among grade 8 students in Kenya. Previous studies considered gender as being a boy or a girl and found a significant relationship with intention to choose physics [29]–[31], this study analyzed the gender of individual learner using a GT assessment tool and then examine the GT relationship with the choice of physics. Further previous studies that investigated attitude [29]–[31] and were mainly descriptive, they noted a significant relationship with interest in the choice of physics. In this paper MS which a broader concept that encompass attitude is assessed using the MS tool and individual learners MS are classified then their relationship with the choice of physics was examined. The section examines literature on how GT and mind set influences STEM choices.

Gender differs from sex in that gender roles are acquired by association with the social environment in which one grows up in. The roles develop as children grow. They are acquired from their interaction with peers, parents, media, and school. The social environment pass on cultural beliefs that describe what is 'appropriate' behavior for male or female [32]. However the gender roles change from time to time with the dynamics of the society [33]. It has been noted that stereotypes influence children's beliefs on what is expected of their social group [34] this further develops their self-perception. Thus when children grow up gender stereotypes influence the way they view themselves and the choices they make [35]. Physics in particular is linked to masculine traits such as abstract, quantitative, outcome oriented, and competitiveness as opposed to the corresponding feminine traits of holistic, qualitative, process oriented, cooperation and objective [6], [36]. This denies most women ability to develop physics identity at high school as such research indicates a negative correlation in development of physics identity due to the girls tendency to lean towards having more personal or/ and family time and opportunities to work with others [37]. This perception of physics from masculine lenses, creates an identity issue on the choice of physic as subject within STEM education [38]–[40].

GT are a set of behavior and interests that are culturally defined to a particular gender [41] and are manifested in psychological traits of masculinity and femininity [33]. The social environment pass on cultural beliefs that describe what is 'appropriate' behavior for male or female [32] and the parents' relationship with their adolescent children is significantly known to propagate GT [42]. However, GT propagation is tempered by socioeconomic status of the environment of the adolescent, which includes location and school status [43], [44]. Previous studies on gender and interest in choice for physics found a significant relationship with choice [29]–[31], [45]. These studies were descriptive and they were conducted in a specific area. This study analyzed the gender of individual learner using Jugović and Kameron, 2016 tool and classified them as strong masculine, masculine with feminine traits, feminine with masculine traits and strong feminine. A relationship of the GT with the interest to choose physics subject was then determined.

Physics was reported as a difficult subject as early as 1935, this has continued with most nations including United Kingdom having a low enrollment in physics at senior high school [12]. Ability strongly predict an educational choice, however it does not fully explain it [46]. The MS set theory is an approach that explains that ability does not fully predict an educational choice. Through the MS approach to learning, an individual learners' analyze their intellectual abilities [47]. If they view their intelligence as fixed, they possess less control of developing their abilities and as such are considered to have a fixed mindset. In contrast if they view their intelligence as malleable, they perceive that they have an ability to change their intelligence levels by effort and struggle. As such these learners are said to possess a growth mindset [48]. When students struggle with school work they respond by either giving up or embracing the struggle thus forming a MS [49].

Students' with a growth mindset (GMS) persevere in their effort and are motivated and committed in their pursuit of academic activities [50]–[52]. GMS helps a student to develop a greater self-identity in physics even if it is considered difficult because they believe that they can do it [53], [54]. This implies that embracing GMS mediates the interest in physics [55]. GMS instills a positive attitude and finds value studying even difficult subjects [56]. On the other hand, fixed mindset (FMS) creates a lower physics identity and makes a learner easily belief society stereotypes many of which make them avoid the STEM education [38].

However, MS type has been noted to be mediated by the socio-economic background with more students from the advantaged socio-economic background having a GMS. The socio-economic background is further influenced by the location of the learner in form of the catchment area around the school, the school attended [43]. Further, the MS of a learner is associated with their academic achievement [57].

Previous studies in Kenya are mainly descriptive and investigate attitude [29]–[31]. They noted a significant relationship with interest in the choice of physics. In this paper, MS which encompass the role of motivation and attitude to sustain interest and persistence in the study of physics was assessed.

2. RESEARCH METHOD

The study adopted a correlational design to examine the relationship between GT and MS with the choice of physics subject among selected students in the Kenyan context. A total of 378 form 2 students drawn from selected secondary schools were randomly selected before they made their subject choices. The rationale for this timing was that this is the class the students decide on choice of physics to the end of high school. Further, the schools were drawn from two counties, one from Central Kenya which is endowed with a wide range of agricultural economic activities and the other one is an arid and semi-arid land (ASAL) region. The two counties are a representative of different socio-economic backgrounds according to the rankings by the Kenya revenue allocation [58].

2.1. Research instrument

The study used an adapted MS questionnaire by Dweck [47] which contains 10 items. The items consist of statements that refers to GMS versus FMS and respectively as shown in Table 1. The MS statements were scored on a 4-point scale "strongly agree", "agree", "disagree" or "strongly disagree". The aggregated sum of all items generated the factor rating with the FMS scored at 10–13 and rated at 1, FMS with some growth ideas scored at 14–22 and rated at 2, GMS with some fixed ideas scored at 23–27 and rated at 3 and strong GMS scored at 28–40 and rated at 4. This test was found valid as it was used in Chile by Yeager and Dweck [49], with a consistency of Cronbach alpha (α)=0.86.

GT questionnaire was used to assess the gender stereotypes of femininity and masculinity [45]. The 14 items as in Table 2 includes indicators each of behavior traits and interests associated with females and male. The statements were score on a 4-point scale "strongly agree", "agree", "disagree" or "strongly disagree". The aggregated sum of all items generated the factor rating with the feminine traits scored at 14–18 and rated at 1, feminine with masculine traits scored at 19–28 and rated at 2, masculine with some feminine traits scored at 29–37 and rated at 3, and masculine traits scored at 38–52 and rated at 4. The test was found valid with a consistency of Cronbach alpha (α)=0.88.

Table 1. GMS and FMS indicators

	GMS	FMS
1.	No matter how much intelligence you have, you can always change it quite a bit	Your intelligence is something very basic about you that you can't change very much
2.	The harder you work at physics, the better you will be	Only a few people will be truly good at physics, you have to be born with the ability
3.	I appreciate when people, parents, coaches or teachers give me feedback about my performance	I often get angry when I get feedback about my performance
4.	You can always change how intelligent you are	Truly smart people do not need to try hard
5.	An important reason why I do my school work is that I enjoy learning new things	You are a certain kind of person and there is not much that can be done to really change that

Table 2. Feminine and masculine traits indicators

	Feminine traits	Masculine traits
1.	I show interest and care of young ones and elderly in the family	I like watching or engaging in sport
2.	I put a lot of attention when dressing to ensure I do some make up	Am interested in how things work e.g., cars, computer, machines
3.	Am interested in doing household jobs such as cleaning the house, washing clothes	I often include cursing exclamations in my speech e.g., shit! damn!
4.	Am interested in reading romantic novels watching soap operas and fashion magazines	I enjoy doing minor repairs
5.	I have a lot of understanding for other people	I find myself commanding the people around me.
6.	I enjoy going to buy house hold goods in the market	I like to look physically dangerous e.g., wear military kind of dressing
7.	I give other an opportunity to air their views in a conversation	I tell people what I think even when I know they are not likely to agree with me

2.2. Data analysis

The GT data was recoded with strong masculine as '1', strong masculine with feminine traits as '2', feminine with masculine traits as '3', and strong feminine as '4'. While the MS data was also recoded with FMS as '0', FMS with growth traits as '2', GMS with fixed traits as '3' and GMS as '4'. These two variables are nominal and qualify as the independent variable. The dependent variable i.e., the intention to choose physics whose response is 'Yes' or 'No' is categorical. This coupled with independence of the observation, which was ensured using the research design whereby the sampled population filled in their individual questionnaire [59] qualified the relationship of the data to be evaluated by Chi-square.

3. RESULTS AND DISCUSSION

3.1. Demographics

3.1.1. Gender and age of respondents

A total of 378 respondents constituting 49.2% female and 50.8% male took part in the study. A total of 78% aged 14 to 17 years, 6.7% were 14 years while 15.3% were above 18 years, the details is shown in Table 3. This implies that most learners are within the UNICEF policy of years in secondary school of 12 to 17 years [60].

Table 3. Demographic data

Demographic		Frequency	Percentage
Gender	Male	186	49.2
	Female	192	50.8
	Total	378	100
Age	Below 14	25	6.7
	14 to 17	295	78.0
	18 and above	58	15.3
	Total	378	100

3.1.2. Intention to choose physics

The intention to choose physics forms the dependent variable. This was analyzed with gender of the learner. Table 4 indicates that 32% of male and 20.1% of female had intention in choosing physics. This compares to the current proportions of 35% of male and 15% of female in the population taking physics after grade 8 [7]–[9]. The percentages indicates that the sample characteristics agree with the national statistics on learners studying physics and is therefore a true representation of the population.

Table 4. Respondents' intention to choose physics subject

			Gender		Total
			Male	Female	
Intention to choose physics after grade 8	No	Count	65	116	181
		% within the No intention	35.9%	64.1%	100.0%
		% within the gender	34.9%	60.4%	47.9%
		% of total	17.2%	30.7%	47.9%
	Yes	Count	121	76	197
		% within the Yes intention	61.4%	38.6%	100.0%
		% within the gender	65.1%	39.6%	52.1%
		% of total	32.0%	20.1%	52.1%
	Total	Count	186	192	378
		% within gender	100.0%	100.0%	100.0%
		% of total	49.2%	50.8%	100.0%

3.2. Gender traits characteristics of the respondents

Gender traits of the learners were classified using the GT questionnaire adopted from [45]. The assessment of gender stereotypes yielded strong masculine as 1, strong masculine with feminine traits as 2, feminine with masculine traits as 3 and strong feminine as 4. The overall GT mean was determined using the aggregate mean of all the items. An overall gender rating of 2.28 as indicated in Table 5. This implies that learners possess an average of the feminine with masculine GT.

The item on interest to do household chores, reading romantic novels/watching romantic soaps operas, going to market to buy house hold goods and looking physically dangerous elicited different perception as indicated by the large dispersion of standard deviation of 1.0. This further agrees with the distribution of GT among the learners as indicated in Figure 1. The feminine with masculine traits is the most common GT at 81.58%. The distribution of GT by gender of the learners as indicated in Figure 2 has the masculine GT has only male, while the feminine GT had only female. However, the masculine with feminine GT had 30.6% the female and 24.1% of the male. The feminine with masculine GT had 68.0% of the female and 75.4% of the male. This indicates 30% of female have obtained some masculine characteristics, while 75.4% of the male have obtained some feminine characteristics. This implies that the traditional GT characteristics have been lost. This agrees with Lips [33] that gender is dynamic as indicated by the observation that the male and female do not fall in the expected traditional GT.

Table 5. Mean score and standard deviation for GT items

GT items	Mean	Std. deviation
I show interest and care of young ones and elderly in the family	3.50	0.628
I like watching or engaging in sport	2.89	0.968
I put a lot of attention when dressing to ensure I do some make up	2.16	0.936
Am interested in how things work e.g., cars, computer, machines	3.19	0.894
Am interested in doing household jobs such as cleaning the house, washing clothes	2.67	1.018
I often include cursing exclamations in my speech e.g., shit!, damn!	2.20	0.977
Am interested in reading romantic novels watching soap operas and fashion magazines	2.76	1.047
I enjoy doing minor repairs	2.75	0.932
I have a lot of understanding for other people	3.07	0.904
I find myself commanding the people around me	2.34	0.953
I enjoy going to buy house hold goods in the market	2.63	1.040
I like to look physically dangerous e.g., wear military kind of dressing	2.16	1.062
I give other an opportunity to air their views in a conversation	3.10	0.873
I tell people what I think even when I know they are not likely to agree with me	3.07	0.942
Overall GT rating	2.28	0. 459

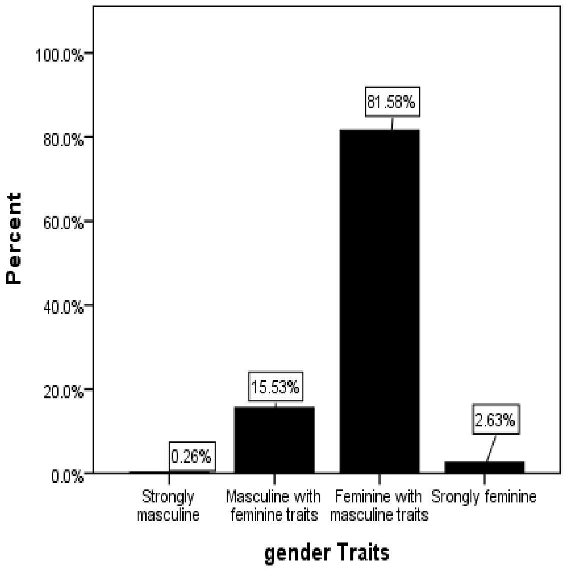

Figure 1. Distribution of GT among the learners

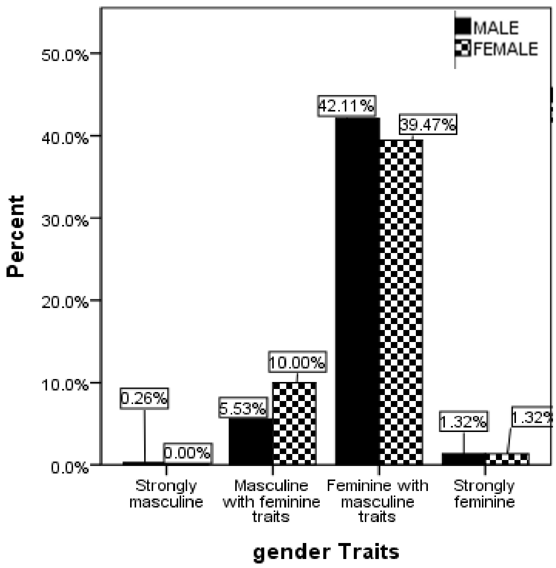

Figure 2. Distribution of GT by gender

3.3. Mindset characteristics of the respondents

Mindset of the learners were classified using responses from the MS questionnaire. Table 6 shows that the overall MS is 3.93% which is the GMS. Some items elicited varied reactions as indicated by the large dispersion with standard deviation of 1.0. This implies that learners held diverse view in their perception of in born ability, how they reacted to comment and complaints from parent's coaches and teachers on their performance, and ability to improve in a subject that one dislikes.

Table 6. Mean score and standard deviation for MS items

MS items	Mean	Std. deviation
Your intelligence is something very basic about you that you cannot change very much	2.88	0.915
No matter how much intelligence you have, you can always change it quite a bit	2.91	0.829
Only a few people will be truly good at physics, you have to be born with the ability	2.01	1.051
The harder you work at physics, the better you will be	3.44	0.818
I often get angry when I get an answer wrong or am corrected in class	2.18	0.984
I appreciate when people, parents, coaches or teachers give comment or complain about my performance	2.98	1.118
Truly smart people do not need to read so much	1.68	0.859
You can always improve in your performance	3.54	0.848
If you don't like physics there is nothing much you can do to improve	2.11	1.031
An important reason why I do my school work Is that I enjoy learning new things	3.13	0.906
MS rating mean score	3.93	0.294

This further agrees with distribution of MS among learners as indicated in Figure 3, 0% have an FMS 7.63% have an FMS with growth ideas while 75% have a GMS with some fixed ideas and 17.4% have GMS. This implies most learners in secondary schools have a strong GMS. When compared with intention to choose physics as indicated in Figure 4, the percentages in each category are almost equal at 4.5% and 3.1%; 39.1% and 36.2%; 3.5% and 3.5%, each for fixed mindset with growth ideas, growth mindset with fixed ideas and growth mindset respectively for those intending to choose and not to choose physics. Thus, there is no GT that has more preference for learners' intention to choose physics.

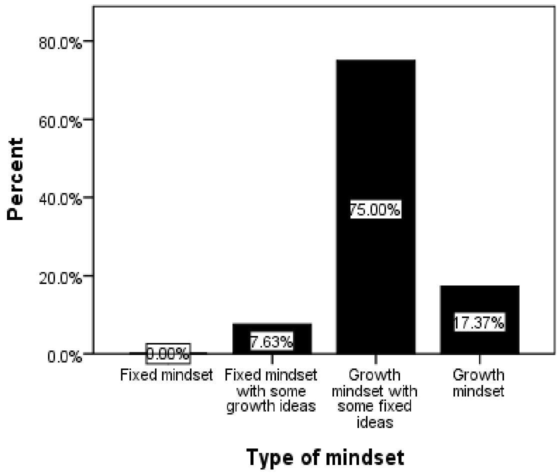

Figure 3. Distribution of MS ideas among learners

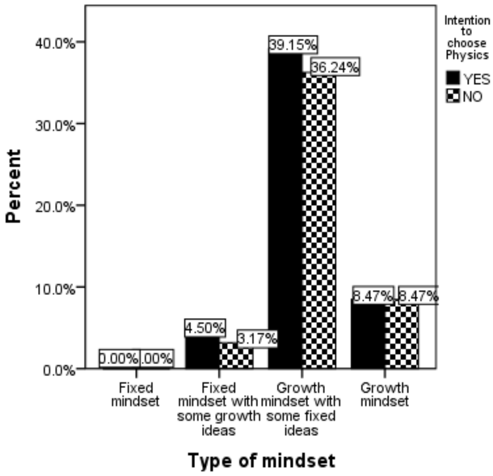

Figure 4. Distribution of MS with intention to choose physics

3.4. Relationship between gender traits and mindset and intention to choose physics subject

To test the two null hypothesis (H_O): there is no relationship between GT and intention to choose physics and there is no relationship between MS and intention to choose physics Chi-square was computed. Table 7 indicates the results with p-value=0.177 for GT and p-value=0.709 for MS. On the both hypothesis p>0.05. This implies a no statistical significance and hence there is no relationship between GT and also there is no relationship between MS and intention to choose of physics. This agrees with characteristics discussed that indicted no GT or MS is preferred for intention to choose physics.

Table 7. Chi-square test for the hypothesis-there is no relationship between the learners' MS and GT with the choice of physics

Independent variable	Dependent variable	Chi test	p-value	Results	Decision
Intention for choice of physics	Learners GT	22.216	0.177	0.177>0.05	H_O accepted
Intention for choice of physics	Learners MS	24.39	0.709	0.709>0.05	H_O accepted

This study reveals that there is no GT that is preferent with the gender of a learner. This is a drift from the traditional norm and agrees with previous study [33] that gender is dynamic. Thus, the social environment has no specific cultural beliefs appropriate for male or female [30]. These characteristics backs the outcome that there is no relationship between GT and intention to choose physics. This disagrees with several researches [24], [26], [29]–[31] that gender is a predictor of physics. The results from these previous studies mainly assumed gender of the learner by their sex while in this study the gender test was actually curried out. These findings imply that the learners have no specific beliefs learned with respect to social interactions appropriate for male or female. This therefore does not influence their subject choices [35], [38], [39]. Thus, the interest to choose physics could be associated with something else but not GT.

The study also reveals that there is no MS preferent with gender of learner or intention to choose, physics. Thus, despite that most learners had some traits of a GMS the learners in almost equal proportions intended either to choose or not choose physics. This could be as a result of difference in personal ability, future aspirations [10], [25], and learners' enjoyment [19]–[28]. These characteristics back the outcome that there is no relationship between MS and intention to choose physics. This disagree with previous studies [53]–[55] that MS mediates subject choice. This reveals that even when a learner has some traits of GMS as noted in this study other factors could determine the subject choice. Others influencers, such as how they view their educational task values such as learners' enjoyment [26]–[28] could come into play MS.

4. CONCLUSION

In the analysis of GT, this study reveals that the traditional gender stereotypes have changed thus there is no GT disparity between male and female. This affirms the assertion that gender is dynamic. Further the hypothesis that there is no relationship between GT and intention to choose physics is affirmed and more so by the findings that no GT are prevalent for the choice of physics, this implies no student is deprived of the opportunity to choose physics subject on account of their GT. This outcome challenges most studies that equated the sex of a learner to gender leading to the notion that gender is a factor that predicts choice of physics. Thus, further studies are proposed to find out exactly why female shy away from physics at high school.

The study also revealed that majority of learners in high school have a tendency towards a GMS with strong FMS been rare and that there is no disparity on the type of MS between male and female. This agree with previous findings the importance of GMS is crucial in high school where learners are exposed to many subjects and determination which is driven by the mindset is key. Further the hypothesis that there is no relationship between MS and the intention to choose physics is affirmed by the findings that there is no MS prevalent for the choice of physics. This implies that no student is deprived of the opportunity to choose physics subject on account of their MS.

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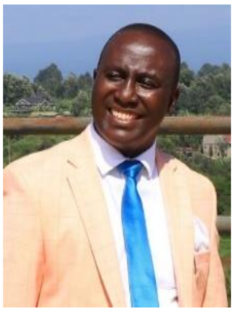

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