Predictors of Students' Participation in Science and Mathematics Subjects in Tanzanian Secondary Schools

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Abstract

This study investigated the factors that predict secondary school students' participation in science and mathematics subjects in Tanzania. The data were collected from 1,382 Form 2 students sampled from sixteen public secondary schools using a validated questionnaire and focus group discussions. Data were analysed by using descriptive statistics, regression analysis, and content analysis techniques. The quantitative findings from regression analysis indicated that prior performance and teachers' instructional feedback significantly predicted students' participation in mathematics and science subjects. Also, students whose parents had higher education were more interested in science and mathematics than those whose parents had lower education. Qualitative findings showed that a shortage of teachers, textbooks, and lab equipment barred students' participation in science and mathematics subjects. The findings call for the enhancement of science and mathematics teachers' instructional and feedback practices to promote a learner-centred learning environment.

Keywords: *predictors, student participation, secondary school, science and mathematics*

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Introduction

Promoting positive attitudes toward science and mathematics has persistently drawn global attention due to its significant impact on students' learning outcomes (Kolne & Lindsay, 2020; Shojaee, 2019). The shortage of skilled workers in Science, Technology, Engineering, and Mathematics (STEM) careers has also prompted several countries to make students' participation in science and mathematics subjects right from the basic education level a priority in preparing future STEM experts (Dickerson et al., 2015). In European nations for instance, education sectors have set strategic plans for strengthening the quality of STEM education by promoting enrolment in science and technical fields (Kearney, 2011). One of these initiatives is to promote school-industry partnerships to foster students' career aspirations in STEM (Kudenko et al., 2017). Similarly, in Africa, several countries have developed strategies to increase investment in science and technology to transform their socio-economic development (Blom et al., 2016). For instance, the Tanzania Vision 2025 recognises science and technology as the main driving force meant to transform the country into a semi-industrialised middle-income economy by 2025. Likewise, the National Science and Technology Policy (URT, 1996) and the Educational and Training Policy (Ministry of Education and Vocational Training [MoEST], 2023) promote the advancement of STEM education as the driver of the country's social and economic development.

In principle, promoting students' participation in science and mathematics subjects has continued to be a priority of several governments as a means to sustain STEM professions. Participation in science and mathematics subjects would increase if most students choose to study those subjects at the basic education levels, i.e., in primary and secondary schools. At the age of 12 to 14 years, students make preliminary choices of subjects for specialization into STEM careers or other academic tracks (Tripney et al., 2010). In the Tanzanian context, students must study science and mathematics subjects such as Biology, Physics, and Chemistry during the first two years of Ordinary level (junior) secondary education (MoEVT, 2023). Then, they can opt out of some of the subjects (except for Mathematics and Biology which are compulsory subjects) while in their third year of secondary education (i.e., Form 3) at the age of 15 to 16 years. Students' choices of subjects are based on their preferences and advice from significant others (Falk et al., 2016). Apart from the perceived benefits of STEM subjects, a good number of secondary school students in Tanzania do not opt for such subjects after compulsory demands (Ndalichako & Komba, 2014). Specifically, the analysis of student enrolment and performance in national examinations (Table 1) reveals that over 75% and nearly 70% of secondary school students choose not to study Physics and Chemistry subjects, respectively, when given the option (MoEST, 2021, 2022). So, this study investigated the factors influencing secondary school students' participation (or lack thereof) in science and mathematics subjects in Tanzania.

Table 1

Enrollment, Performance, and Drop-out Rate of Optional STEM Subjects in CSEE

Subject	Year	Sat for Examinations	Passed the Examinations	Failed the Examinations	Opted-out the Subject
			Total (%)	Total (%)	Total (%)
Physics	2021	115,846	64,096 (55)	51,750 (45)	368,552 (76)
	2022	114,144	78,009 (68)	36,135 (32)	406,255 (78)
Chemistry	2021	151,118	139,054 (92)	12,064 (8)	333,280 (69)
	2022	155,007	145,215 (94)	9,792 (6)	365,392 (70)
Biology	2021	484,398	325,656 (67)	158,741 (33)	0 (0)
	2022	520,399	353,046 (68)	167,353 (32)	0 (0)
Mathematics	2021	484,439	94,677 (20)	389,761 (80)	41 (0)
	2022	520,332	104,488 (20)	415,844 (80)	67 (0)

Note. CSEE = Certificate of Secondary Education Examinations

Before making their selection of subjects, boys, and girls participating in science and mathematics subjects tend to be at par in number. A study by UNESCO (2017) in the UK found that by the age of 10 to 11 years, boys and girls participate relatively equally in STEM subjects but the proportion falls to one-third for boys and one-fifth for girls in seven years. While the available data indicates that the gender gap in students' participation in STEM subjects increases as students advance in their studies (Falk et al., 2016), the potential reasons for low participation and gender disparity are not well-known. In the Tanzanian context, the gender discrepancy in students' participation in STEM subjects emerges in Form 3 when the students make their subject choices. Here, several questions need to be addressed such as: why do most students drop STEM subjects once given a chance to make choices? Why do more girls drop STEM subjects compared to boys? These questions deserve research attention in the Tanzanian context because students' participation in science and mathematics subjects does not match the increased need for STEM experts. Also, gender disparity in participation in STEM subjects perpetuates gender disparity in access to STEM-related opportunities.

Students' participation in science and mathematics subjects

One of the strategies to understand the reasons behind students' low participation in STEM is investigating their attitudes such as interest, enjoyment, and self-efficacy in science and mathematics subjects (Tai et al., 2022). Students with positive attitudes employ more effort and persevere through challenging STEM tasks (Erol & Canbeldek, 2023), develop a deeper understanding of concepts, overcome learning challenges, and ultimately specialise in STEM-related careers (Erol & Canbeldek, 2023). Studies show that positive attitudes significantly impact student engagement and achievement (İnce, 2023; Usher & Pajares, 2009). Students' attitudes towards science and mathematics subjects vary as they advance to higher levels of education (Carr et al., 2023), and partly depend on the quality of classroom practices such as feedback-giving processes (Kyaruzi et al., 2019; Wood, 2019). However, there is mixed research evidence from which researchers can confidently formulate research hypotheses. For example, while there is substantial evidence of an association of self-efficacy with performance and persistence in STEM subjects (Erol & Canbeldek, 2023; Usher & Pajares, 2009), mixed results are reported on the role of attitude on performance (Erol & Canbelde, 2023).

The present study was guided by the self-determination theory which emphasises the role of intrinsic and extrinsic motivation in the successful completion of a task for an expected reward (Deci & Ryan, 2013). Intrinsic motivation is rooted in internal feelings (e.g., I need STEM subjects because they are good), while extrinsic motivation is a product of external drives (e.g., I need STEM subjects because they are associated with highly paying jobs) (Rosenzweig et al., 2019). Motivated students are more likely to do well in STEM subjects unlike the less motivated ones (İnce, 2023; Usher & Pajares, 2009). According to the self-determination theory, individual performance in STEM-related tasks depends on the sense of self-efficacy (autonomy), perceived high competence accumulated from previous performance, and an inclusive pedagogy in the learning process (relatedness). Accordingly, students' relatedness in terms of positive relationships with teachers, affective relationships, and feedback promotes their participation in classes and subsequent performance (Wood, 2019). For several decades, teacher feedback has been reported to have a significant effect on students' perception of their efforts and abilities (Schunk, 1984). However, the impact of feedback on students' self-efficacy and participation in learning can vary significantly depending on how it is delivered (Kyaruzi, 2019).

An investigation into student participation in STEM subjects in the Tanzanian context necessitates the analysis of gender dynamics, particularly due to the documented gender gaps in students' performance in STEM subjects. Gender consideration is also in line with the Sustainable Development Goals (SDGs) 4 and 5 which call for the promotion of equal access to quality education at all levels of education and the elimination of gender disparity in education by 2030 – including STEM subjects (UNESCO, 2017). While Dasgupta and Stout (2014) noted that the gender gap in science and mathematics performance is closing in developed countries, studies conducted in the African context show that girls still lag behind in STEM subjects (Dickerson et al., 2015) due to sociological and psychological factors among others (Matete, 2021). Conventionally, girls have been lagging behind in accessing science and mathematics education due to biased gender roles gender stereotyping, and inadequacy of school facilities (Kyaruzi, 2023; Eriksson et al., 2021). Consequently, girls' participation in science and mathematics education has been relatively lower than boys even though several policies have been implemented to address the associated barriers (UNESCO, 2017). However, research does not tell us much about why the ongoing affirmative actions have not adequately addressed gender disparities, particularly in developing countries.

Problem statement and research questions

According to the Basic Educational Statistics in Tanzania [BEST], there is low student participation in optional STEM subjects coupled with a gendered performance gap favouring male students (Ministry of Education, Science, and Technology [MoEVT], 2020). Consequently, students' poor performance in secondary schools best explains the comparatively low university enrollment in STEM-related careers (Mpehongwa, 2014).

Several studies in Tanzania (e.g., Kinyota, 2023; Matete, 2021) have addressed STEM participation at the tertiary level, while others (e.g., Kabote et al., 2014) have focused on performance and participation at the primary school level. Only a few studies (e.g., Kibona, 2023) have investigated students' participation in science and mathematics subjects at the secondary school level, which plays a critical role in supplying universities with students for future STEM professions. While previous studies provide valuable information on the problem of students' performance in STEM subjects, they have not addressed the root causes of low participation in science and mathematics. This study investigated the predictors of secondary school students' participation (or lack thereof) in science and mathematics subjects in Tanzania. Specifically, the study investigated the following research questions:

i. To what extent do students participate in secondary science and mathematics subjects in terms of mathematics attitude, science attitude, and feedback use?

ii. How much of the variance in students' participation in science and mathematics subjects can be predicted by demographic variables (primary school performance, gender, parents' socioeconomic status) and teacher feedback practices?

iii. What factors hinder secondary school students' participation in science and mathematics subjects? How could they be addressed?

Methodology

The study was conducted in sixteen secondary schools from two regions representing two geographical zones in Tanzania. In each region, stratified random sampling was used to sample two districts based on their geographical locations (i.e., urban vs. non-urban) – where one urban district and one non-urban district were selected. Then, four secondary schools were randomly selected in each of the districts. In each of the sampled secondary schools, Form 2 students were invited to participate in the study because at this class level students are about to specialise (when they enter Form 3) in either STEM-related subjects or other subjects. Participation in the study was voluntary whereby the students were asked for their consent after being informed about their rights such as the right to seek clarification, and the right to withdraw from the study at any point without any consequence. Table 2 summarises the demographic characteristics of 1,382 Form 2 students (mean age 15.6 years) who participated in the study.

Table 2

Demographics of Participating Students and Schools Split by Gender

Demographics	Female	Male	Total
Location			
Rural	393 (55.5%)	332 (49.3%)	725 (52.5%)
Urban	315 (44.5%)	342 (50.7%)	657 (47.5%)
Parents' highest education	201 (28.8%)	198(30.1%)	400 (29.5%)
Primary	324 (46.5%)	294 (43.6%)	618 (45.6%)
Secondary	74 (10.6%)	69 (10.5%)	143 (10.6%)
Diploma	30 (4.2%)	43 (6.5%)	73 (5.4%)
Bachelor degree	68 (9.6%)	54 (8.2%)	121 (8.9%)
Master's degree and above	589 (90.9%)	555 (92.5%)	1144 (91.7%)
Mothers' occupation	59 (9.1%)	45 (7.5%)	104 (8.3%)
Self-employed	525 (82.0%)	504 (82.6%)	1029 (82.3%)
Employed	115 (18.0%)	106 (17.4%)	221 (17.7%)
Fathers' occupation			
Self-employed			
Employed			

Note. Participants (%), Mean (Standard deviation)

Research design

This study employed a mixed-methods research approach. A concurrent triangulation research design was used in which the qualitative and quantitative data were collected simultaneously (Dingyloudi & Strijbos, 2018). Particularly, the study assumed a pragmatic worldview which is in line with mixed methods research. The mixed methods research approach suited the study because a combination of qualitative and quantitative data makes it possible to benefit from the strengths of each method. The qualitative component of the study enabled the researcher to gain an in-depth understanding of the factors influencing students' participation in STEM subjects through focus group discussions, meanwhile, the quantitative component helped explore students' attitudes towards participation in science and mathematics subjects by collecting data from a relatively larger sample.

Instruments

Data were collected using a questionnaire and focus group discussions with students. Quantitative data were collected using the previously validated '*Upper Elementary School and Middle/High School Student Attitudes toward STEM* (S-STEM) (Unfried et al., 2015). The feedback utility scale was also adopted from the '*Instructional Feedback Orientation Scale (IFOS)*' (King et al., 2009) to measure students' perceptions of the quality of teachers' instructional feedback. All items were adapted to a balanced six-point Likert scale ranging from 1 = Completely Disagree to 6 = Completely agree. The adopted scales were previously validated by some studies in the Tanzanian context – IFOS (Kyaruzi et al., 2019) and S-STEM (Kyaruzi et al., 2021). Other independent factors such as gender, parents' education, and prior performance were included in the questionnaire as demographic variables. Students reported their parents' or guardians' highest education level on a five-point scale from "primary education" to "master's degree and above". Parents' level of education and occupation (measured as employed or self-employed) were used as a measure of socioeconomic status. Also, students' prior performance in the Standard 7 national examinations was obtained from the National Examinations Council of Tanzania (NECTA) database using students' reported examination numbers. Table 3 summarises the scales, a sample item per scale, and the scale internal reliability Cronbach's α from the original and the present study.

Table 3

Sub-Scales, Sample Items, Mean Scores, and Estimates of Reliability

Sub-scales	Sample item	Mean (SD)	k	*Study* Cronbach's α *Original*	*Present*
Mathematics attitude	I would consider choosing a career that uses math.	3.98 (.92)	8	0.85	0.88
Science attitude	I expect to use science when I get out of school.	4.62 (.91)	9	0.83	0.83
Mathematics Feedback Use	I feel relieved when I receive positive feedback from my Mathematics teachers.	5.03 (.84)	9	0.85	0.87
Science Feedback Use	I feel relieved when I receive positive feedback from my science teachers.	5.12 (.86)	9	0.85	.89

Note. SD = Standard deviation, k = Number of items

In addition to the questionnaire, eight focus group discussions (FGDs) were conducted with 48 students from eight sampled schools distributed into rural and urban districts. FGDs were conducted in eight out of the sixteen schools (50%) with at least one school in each district and there was equal representation of girls and boys. Participants were sampled from among those who showed a willingness to participate in the FGD when responding to the questionnaire. An example of the discussion questions is: – Would you like to undertake a professional career that involves STEM subjects or not? Please give reasons for your answer. The average duration of the FGDs was 33 minutes.

Data analysis

The data were cleaned to eradicate any wrongly entered data and the missing values analysis were analysed. The analysis of missing values was conducted whereby 48 respondents (4%) with more than 10% missing values were excluded from the dataset, making the study remain with 1,382 respondents. The remaining missing values were completely missing at random (MCAR) with Little's MCAR test ($\chi2 = 88.56$, df = 82, $p = 0.29$) as Peugh and Enders (2004) argue that data are MCAR when Little's MCAR test is not statistically significant. Subsequently, the expectation-maximization method was used to impute the missing values for it is considered a useful imputation technique with data MCAR (Musil et al., 2002). Skewedness and kurtosis values were below 2 and 4 for each sub-scale respectively, which means that the data met the normality assumption (Finney & DiStefano, 2013).

The data were analysed using descriptive statistics, regression analysis, and content analysis techniques. Particularly, the qualitative and quantitative data were analysed using relevant data analysis software. The FGDs were recorded verbatim by using a voice recorder and thereafter transcribed. The transcripts were entered into the MAXQDA software for analysis using content analysis procedures (Braun & Clarke, 2006). To determine inter-rater coding reliability, the obtained code segments were coded by two independent coders whereby an inter-rater agreement of Krippendoff's value of 0.79 was attained with a coding agreement of 89.4%, which is an ideal level of agreement. The inter-rater disagreements were discussed among the raters and resolved, leading to the agreement to use the dataset with many code segments. Finally, the themes were quantified and participants' quotes were summarised for presentation. Meanwhile, the quantitative were analysed by using descriptive and regression analyses with the help of SPSS version 25.

Results and Discussion

Students' perceptions of participation in science and mathematics subjects

This study investigated the factors influencing secondary school students' participation (or lack thereof) in science and mathematics subjects in Tanzania. The first research question was on how students perceive their participation in science and mathematics subjects in Tanzanian secondary schools. Data for this question were descriptively analysed. The findings indicated that students' attitudes in science and mathematics varied across subjects. Specifically, students had a positive attitude toward their participation in science ($M = 4.62$, $SD = 0.91$) and somewhat in Mathematics ($M = 3.98$, $SD = 0.92$) as indicated in Table 3. Although Mathematics is considered the gateway to STEM professions, it was the least preferred subject. This suggests that to enable students to pursue STEM careers, efforts should be made to promote students' attitude to participate in Mathematics. Besides, further analysis was conducted to find out whether students' participation in science and mathematics varied by gender and parents' socioeconomic status. The findings indicated that students' attitudes towards participation in Mathematics significantly differed by gender, with the male students having more positive attitudes than their female fellows. Also, participation in Mathematics significantly differed between rural and urban students, with the students studying in urban schools being more interested than their fellows from rural schools (see Table 4). The observed differences in students' attitudes towards participation in some of the STEM subjects could also explain the gender discrepancy in students' performance. Regarding the quality of teacher feedback, students had a positive perception and were willing to use teacher feedback to improve their learning.

Table 4

Student Participation in STEM across Gender and School Location

Construct	Gender			*Location*		
	Female	Male	*t-value*	*Rural*	*Urban*	*t-value*
Mathematics attitude	3.91 (.90)	4.06 (.94)	-3.053*	3.89 (.92)	4.09 (.90)	-4.122*
Science attitude	4.59 (.90)	4.66 (.92)	-1.381	4.64 (.86)	4.60 (.95)	0.813
Mathematics feedback use	5.04 (.82)	5.03 (.87)	3.66	5.05 (.83)	5.01 (.86)	0.928
Science feedback use	5.16 (.81)	5.09 (.92)	1.557	5.20 (.78)	5.04 (.94)	3.524*

Note. Mean (SD) = Standard deviation, * p< .001

Further analysis of the data from focus group discussions indicated that several motives make students interested in participating in STEM subjects. Almost half of the students (48%) were interested in specializing in STEM subjects to fulfil their career aspirations. Particularly, these students were aware that being a doctor or an engineer requires one to study STEM subjects. The second reason for students' participation in science and mathematics subjects was related to the increasing demands of STEM experts at the national and global levels. Specifically, students pointed out that national plans for the efforts to become a middle-income economy by 2025 prioritise STEM subjects. Similarly, students acknowledged that the global agenda requires scientists, who are obtained from individuals who pursue STEM subjects. The perceived high employability of STEM graduates was another motive for students' participation in science and mathematics subjects as revealed by the words of one student who said, *'...there are high employment opportunities in science careers, I want to be among the few (School 1)*'. Lastly, the students noted that science and mathematics are essential in addressing societal problems. Specifically, they pointed out that as the country, science and technology experts are highly needed in addressing societal problems such as health, infrastructure, and nutrition-related challenges.

The findings for this question indicated that students positively rated their participation in science and mathematics subjects, with mathematics having the lowest rating. These findings underscore the need to promote students' positive attitude and participation in Mathematics as a gateway to STEM professions. While mathematics is considered the mother of STEM professions, students had low attitudes toward participation in it despite being potential in inculcating science and mathematics values among future experts (Dickerson et al., 2015). Based on the findings, the future of science and mathematics fields highly depends on the promotion of positive attitudes towards science and mathematics subjects. Qualitative findings indicated that students were interested in science and mathematics subjects due to career aspirations and the need to increase employability chances, something which is also reported in previous studies (Rosenzweig et al., 2019). Unlike previous studies, the findings of the current study indicated that students were driven by the problem-solving approach in the sense that science and mathematics careers are likely to address the challenges facing their community. Also, students were informed that science and mathematics education feeds into national priorities and plans. The analysis of the scale's interrelations indicated that students' attitudes to participate in science, and mathematics were moderately related, implying that the promotion of science and mathematics education needs to be holistic, focusing on all related subjects as opposed to subject-specific interventions.

Predictors of students' participation in science and mathematics subjects

The second research question was on the extent to which the variance in students' participation in science and mathematics subjects is predicted by their entry performance, gender, and parents' socioeconomic status. The results of regression analysis indicated that students' participation in mathematics learning was significantly predicted by previous grades in that subject (in Standard 7), father's occupation, school location, and the perceived usefulness of teacher feedback on tests and examinations. Table 5 presents the predictors of students' attitudes toward participation in science and mathematics subjects.

Table 5

Predictors of Students' Participation in Science and Mathematics Subjects

Variable	[a]Mathematics (β)	[b]Science (β)
Mathematics grade	.284**	-
Science grade	-	.090*
Gender	.056*	.054
Parent's education	.034	.060*
Fathers' occupation	-.063*	-.017
Mothers' occupation	-.015	-.035
Location	.051*	-.016
Feedback use	.324**	.466*

Note. **p<.001, *p<.05

[a]Test statistics: adj. R^2 = .254, F (9, 241) = 42.22, p = .000, f^2 = 0.34

[b]Test statistics: adj. R^2 = .270, F (9, 228) = 45.84, p = .000, f^2 = 0.37

The findings in Table 5 indicate that students' participation in science subjects was significantly predicted by their previous performance in science, parents' education level, and the perceived usefulness of teacher feedback on science tests and examinations. Generally, prior performance in the standardised Standard 7 national examination in a particular subject and the perceived usefulness of teachers' instructional feedback emerged as the strongest predictors of students' participation in science and mathematics. Meanwhile, gender was a significant predictor of students' involvement only in mathematics, implying that the subject is gendered due to the existence of gender stereotypes favouring male students. Concerning Cohen's (2016) interpretation of effect size, the predictors significantly affected students' attitudes toward mathematics (explaining 34% of the variance) and 37% of the variance in science attitude.

Findings indicated that students whose parents had higher education were more interested in mathematics and science than those whose parents had lower education. These findings resonate with previous studies which have established that students' performance in STEM subjects is highly related to the socio-economic status of the parents, especially in developing countries (Eriksson et al., 2021). Particularly, in societies where teaching and learning resources are scarce, parents have a role to play in facilitating their children's education by purchasing those resources and providing cognitive and social support to their children, which is significantly related to academic performance (Kyaruzi et al., 2019). This could also explain the perceived support that students get from their parents, which partly includes the provision of teaching and learning materials. Unlike in previous studies (e.g., Kinyota, 2023), gender, parent's education, and mother's education did not predict students' participation in mathematics learning. Nevertheless, the findings point to the significant impact of previous performance or grade in predicting secondary school students' learning of mathematics and science. Therefore, there is a need to build a strong STEM foundation at the lower education levels. Likewise, teachers' instructional feedback was found to be a strong predictor of students' interest and participation in science and mathematics subjects. This points to the power of feedback in scaffolding students' learning (King et al., 2009; Kyaruzi et al., 2019), promoting interest in the subjects, and making learners highly self-efficacious (Bandura, 1997; Deci & Ryan, 2013).

Barriers to students' participation in science and mathematics subjects

The third research question was on the factors that hinder students' participation in science and mathematics and how they could be addressed. The analysis of data from focus group discussions with students indicated that several factors hindered students' participation in science and mathematics including a shortage of teachers (33%), a shortage of textbooks and inadequacy of lab equipment (33%), and discouragement from peers and adults (34%). Table 6 summarises the hindrances of students' participation in science and mathematics subjects.

Table 6

Barriers to Students' Participation in Science and Mathematics Subjects

Construct	Sample focus group excerpts
Shortage of Science and Mathematics teachers (N = 9, 33%)	…There is a shortage of science and mathematics teachers – the few available teachers are teaching examination classes (School 5).
Shortage of textbooks and lab equipment (N = 9, 33%)	…there is rare lab testing in the laboratory due to a lack of lab equipment, and a scarcity of science textbooks (School 2)... We do not conduct practicals and demonstrations; I have never done practicals since Form 1 (School 3).
Discouragement from peers and adults (N = 10, 34%)	…Sometimes when studying science, we are discouraged by our fellow students (School 6)……We are discouraged by art teachers not to take science and encourage us to study arts subjects (School 3).

The findings in Table 6 imply that students' participation in science and mathematics subjects is affected by a shortage of teachers. Particularly, students reported that in some science and mathematics subjects, they had one teacher who was mainly assigned to teach examination classes. It was noted in one school that most teachers gave excuses for not teaching due to tiredness after teaching several classes without a break as evidenced by the focus group discussion excerpt below:

> The collaboration between teachers and students is not strong. In science, the teacher needs to attend classes regularly and ask many questions. However, in our school, we find that teachers are few and they still have a lot of other responsibilities, which is a challenge (School 3).

Another challenge was the acute shortage of textbooks and lab equipment, which limited students' learning opportunities. While many schools had buildings for science laboratories, they had limited lab equipment and chemicals which confined them to theoretical learning because the laboratory chemicals and equipment available were reserved for examination classes. This was elaborated by one participant during a focus group discussion, who said:

> The main challenge we are experiencing is the shortage of laboratory and equipment. First of all, we have a Physics laboratory, which contains all the equipment for Biology and Chemistry as well, so there is a mixture of equipment which leads to disturbance. Also, we don't have

> enough equipment to study science subjects practically. For instance, when doing the simple pendulum experiment, we use a stopwatch and others use a normal watch, which could mislead us (School 6).

Furthermore, the students were discouraged from taking science and mathematics subjects by fellow students and by other teachers (non-science teachers). Due to the persistent failure in science and mathematics subjects, especially Mathematics and Physics, the students were told that, like others, they would eventually fail in those subjects. The following excerpts from students and teachers attest to this:

> Another challenge is peer pressure. For example, in class, if other students see you studying Science and Mathematics, they discourage you, telling you something like, 'Didn't you see so-and-so last year? They were excelling in science but failed in the end. So, you shouldn't focus on science, it's better to do arts subjects (School 5).

> Some teachers sometimes discourage us from pursuing our interests. For instance, an art teacher who originally wanted to study science might discourage you from studying chemistry, saying it is too difficult. This lack of support makes it hard for us to decide what we want to study (School 1).

Lastly, due to poor pedagogical skills, particularly the skills of handling students who fail in these subjects, teachers resort to the use of poor instructional practices such as punishment. Such ill practices evoke anxiety toward participation in science and mathematics subjects, subsequently lowering students' performance.

The analysis of the findings indicated that science and mathematics education was hampered by a shortage of resources – human resources (subject teachers) and material resources (textbooks and lab equipment). The shortage of teachers is considered a strong barrier because, with the presence of teachers, students are likely to excel in science and mathematics subjects irrespective of other constraints. The findings further revealed that schools suffer a lack of textbooks and lab equipment needed to aid science learning. While textbooks and lab equipment are essential in promoting authentic learning, the findings indicated that they are in a dire shortage in school, hence students are likely to learn superficially. Based on the findings, there is a pressing need to promote meaningful science and mathematics learning through practice-based methods. Likewise, students' science and mathematics learning were barred by social factors such as being discouraged by peers and significant adults. In particular, previous studies show that there exists a societal bias towards the subjects, especially Mathematics and Physics which are perceived as difficult subjects. Such societal bias discourages students from pursuing science and mathematics subjects. Hence, there is an urgent need to promote scientific literacy in the community as the precursor for potential scientists and mathematics experts (Falk et al., 2016). Lastly, the findings showed that students' science and mathematics learning was hindered by teachers' use of ill-pedagogical practices such as punishing the students during the learning sessions. This calls for positive interactive approaches and feedback practices to be used to promote relatedness and student engagement (Kyaruzi et al., 2019; Wood, 2019).

Based on the findings, several theoretical and practical implications can be drawn. First, given that students positively perceive science and mathematics subjects, they are likely to pursue STEM-related careers if there is a conducive learning environment with enough human and material resources. Consistent with self-determination theory, the findings emphasise the role of a conducive learning environment, which depends on parents' socioeconomic status on students' attitudes towards STEM subjects. Also, students' attitudes toward science and mathematics were highly related, calling for a holistic approach to promoting science and mathematics education as opposed to subject-focused interventions. This is again consistent with the self-determination theory, which postulates that students' prior performance predicts students' attitudes and participation in those subjects (Chiu, 2024; Deci & Ryan, 2013). The implication of this is that successful interventions should begin at lower levels such as the primary school level. The findings advocate for earlier interventions for students' interests that vary across education levels (Carr et al., 2023). Additionally, the fact that instructional feedback was a strong predictor of students' participation in science and mathematics subjects is a call for teachers to use effective instructional practices that scaffold students' learning (Kyaruzi, 2019). In contrast, ill-instructional practices such as poor punishment cause students to shy away from participating in science and mathematics subjects. Science and mathematics teachers need to be oriented by using innovative and learner-centred pedagogies that place learners at the centre of the learning process. As Kyaruzi et al. (2019) argue, formative feedback that scaffolds student learning promotes students' participation and performance in those subjects.

Also, the findings indicated that resource-based, relational, and pedagogical-based challenges barred students' participation in science and mathematics subjects. These need to be addressed to promote science and mathematics education. Particularly, there is a pressing need to recruit more science and mathematics teachers and educate the community on the role of scientific knowledge to get rid of the reported stereotypes towards science and mathematics subjects. Lastly, while Marks (2008) found that the mother's occupation was a significant predictor of students' performance in several countries, the current study did not find any evidence for that. This could be attributed to the nature of the sample used as 90% of the mothers had low levels of education. These findings call for further inquiry into the matter by using a systematic sample considering various education levels and occupations of parents. Demographic variables such as students' gender and parents' socio-economic status and education levels interacted with students' attitudes towards and choices of science and mathematics. Specifically, the findings revealed that students whose parents had higher education (graduates and above) had more positive attitudes towards participating in mathematics and science subjects compared to students whose parents had lower education. The findings call for improved levels of society education, with the government initiatives to extend basic education from primary to secondary levels (MoEVT, 2023).

Conclusion

Although students showed a positive attitude towards participation in science and mathematics subjects, their performance in those subjects was not promising, calling for strategic interventions to address the associated barriers. Such interventions need to be timely to realise the national strategic plans for fostering scientific development. Extending the relatedness aspect of the self-determination theory, the findings call for improved science and mathematics teachers' instructional practices that value and place learners at the centre of the learning process. The findings highlight the positive impact of teachers' instructional feedback practices on students' participation in mathematics and science subjects. The findings from this study are significant to other educational systems that struggle to improve students' participation in science and mathematics subjects. Nonetheless, although data for this study were systematically collected and analysed, findings could be substantiated with evidence from studies with longitudinal and experimental designs. Since this study was conducted in public schools, future research could explore students in other school categories, including private schools, which may offer different learning environments. Kibona (2023) highlights that some private schools exhibit no gender gap in students' performance in science and mathematics. Future studies could also examine the impact of parents' socioeconomic status on students' participation and performance in private and public schools to inform strategic interventions in promoting equity in science and mathematics subjects.

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