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Learners' perception of perceived physics difficulty: association with choice at the elective level in high school

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ABSTRACT

This study presents a regression-based correlational survey that investigates how high school students' perceptions of physics difficulty influence their decision to select the subject at the elective level. Although physics is foundational to technological advancement, student enrollment particularly among females remains low. This study is analytical research that explores three core dimensions of perceived physics difficulty (PPD): subject allure (SA), content factors (CF), and teacher factors (TF). Using a descriptive survey and logistic regression analysis, data were collected from 378 form two students. Results revealed that only SA significantly predicted students' choice of physics, despite generally positive perceptions of teacher engagement. Students who opted for physics found it fascinating and relevant to their daily lives. Teacher influence was statistically insignificant, and content difficulty demonstrated a weaker but notable association. The findings suggest that increasing the subject's appeal and perceived relevance may be more effective in improving uptake than focusing solely on pedagogical practices. These insights offer strategic directions for curriculum design and education policy aimed at promoting science, technology, engineering, and math (STEM) engagement and advancing educational equity. This study presents the first predictive model of physics subject choice in Kenya using logistic regression.

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1. INTRODUCTION

Physics plays a vital role in technological advancement by equipping learners with foundational knowledge essential for engineering and scientific innovation globally [1]. However, physics enrollment at the tertiary level remains low, with female participation notably lagging behind that of males [2], [3]. In Kenya, national data from 2017 to 2020 indicates that only 26-27% of secondary school students annually enroll in physics [4], [5]. Notably, the gender gap persists, with 35% of male enrolled compared to only 15% of female students. This trend is concerning given the critical role of physics in achieving Sustainable Development Goal 4 (SDG-4), which aims to promote inclusive, equitable, and quality education and support sustainable industrialization and innovation [6]. Despite the subject's importance and its potential to open doors to a range of science, technology, engineering, and math (STEM)-related careers, many students avoid physics. This raises a crucial question: is physics perceived as inherently difficult or complex, prompting students to opt out?

This study presents the first predictive model of physics subject choice in Kenya using logistic regression. This is achieved by addressing a methodological gap in existing studies, which predominantly rely on qualitative analysis of individual factors influencing physics choice. By employing a regression-based approach, this study evaluates the predictive power of teacher factors (TF), content factors (CF), and subject allure (SA) dimensions of perceived physics difficulty (PPD). The research seeks to answer the question: i) what is the relationship of TF, CF, and SA to students' selection of physics at the high school elective level? and ii) what is the contribution of TF, CF, and SA to students' selection of physics at the high school elective level?

While academic ability alone does not determine subject selection [7], some students who perform well in mathematics and physics pursue careers unrelated to these subjects [8]. This trend may be attributed to PPD, a longstanding issue first identified as early as 1935. PPD is often shaped by course content, teacher engagement, and student-specific factors [9]–[11]. Additionally, learners' aspirations and perceptions are influenced by personal experiences, peer opinions, and the conceptual complexity of the subject [12]–[14]. Studies indicate that teachers plays a central role in mitigating PPD This depends on their ability to employ various teaching and learning strategies [15]–[17]. Through these strategies, the teacher controls most predictors by making the learner interact with the content more easily at their level [17]. This further develops a positive attitude, motivation, and study discipline [15]. The teacher can also mitigate the PPD by cultivating a good relationship with the learners [18], [19]. In doing so the teacher can influence the learners through advice on prospects available due to the subjects they teach and also through the school policy formulated at the school level on subject selection [20]. This instills in the learners the ability to do their best [21].

Physics is often perceived as the most difficult of the sciences in high school, as a result most learners avoid it when it is optional due to fear of failure [21]. This perception makes physics content a crucial factor to PPD. However, many studies have argued that the subject content challenges the learner's cognitive abilities and personal effort [8], [22].

According to Linn [8] that the physics content is difficult because it mainly involves problem-solving, and even with much practice, the questions in the exam are challenging [16]. Further argue that solving physics problems requires high-order thinking skills, and most problems involve equations that use symbols to express oneself. Other studies have put forth that physics is complex because most of the content is not familiar to the learners' environment [23], and many topics before the point of selection of the subject are challenging to the learner [9], [14]. Students' concerns about their academic ability and their interactions are also seen as another source of PPD [9], [24], [25]. These factors strongly correlate with academic performance, shape self-expectations, and are influenced by peer comparisons [11]. Additional studies reveal that students tend to align cognitively with their peer groups, which in turn affects their subject choices [26], [27]. However, research also shows that peer influence is moderated by individual achievement [19].

Gender identity is another important predictor of physics enrollment [28], [29], it has contributed significantly to the lack of equity and inclusivity in physics [30]. Gender is closely linked with the learners' perceived value of physics and future aspirations [19], [29], [31]. The value-expectancy theory by Wigfield and Eccles [32] further suggests that learner's gender ideologies influence educational choices by shaping task values such as learners' interest and usefulness of a subject to future goals, the importance to do well and the learners' self-perception which is the way they view themselves [7].

Additionally, students' attitudes, discipline and motivation towards science subject play a key role in generating interest and enjoyment [9], [19], [25], [29]. This could STEM from which schools the learner will attend, the quality of teaching and learning in those schools, information/advice availed to learners, and parental involvement in the guidance of the learners in these schools [12]. However, the socio-economic status (SES) background determines the quality of these and, consequently, the familiarity with the physics content and future opportunities for the learner. Studies have shown that SES background is linked to subject choice, especially in STEM subjects [29]. This interrelationship of variables in determining the choice of physics subject in high school is expressed in the conceptual framework in Figure 1.

Studies show before university or college entrance low enrollment in physics occurs [2]. Therefore, there is a need to examine the predictors of the choice of physics and understand their magnitude of impact on enrollment [33]. The findings in this study will assist policy makers in identifying areas to focus in the in-service training and content evaluation in order to ensure an increase in the numbers of students taking physics to the end of high school. This places more learners in a position to take up STEM related courses and careers and thus provide a nation with the much desired labor force to attaining the SDGs, including: ensuring inclusive and equitable quality education and promote lifelong learning for all, achieve gender equality and empower women and girls, build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation and above all end poverty [6].

The objective of this article is to: i) determine the relationship of the TF, CF and SA of PPD to the choice of physics at the high school level and ii) to determine the contribution of the TF, CF, and SA of PPD to the choice of physics at the high school level. The hypothesis of the study was i) there is no relationship and contribution by teachers', content, and SA dimensions of PPD in learners' choice of physics subject at high school and ii) there is no contribution by teachers', content, and SA dimensions of PPD in learners' choice of physics subject at high school.

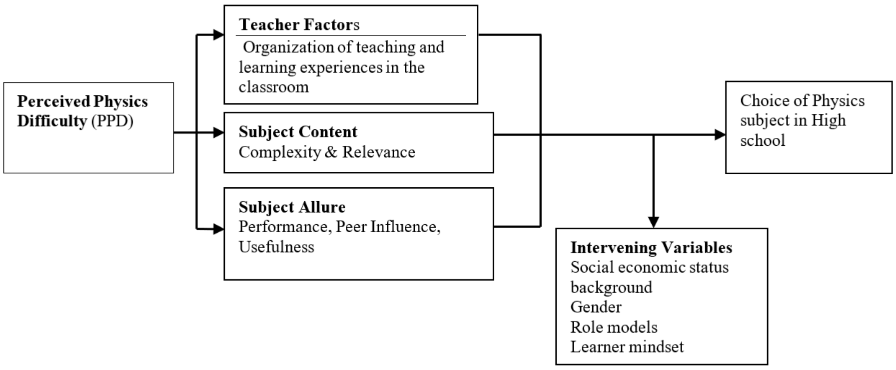

Figure 1. Conceptual framework on physics subject choice in high school as predicted by PPD

2. METHOD AND MATERIALS

2.1. Research design

This study is mainly analytical research that adopted a regression-based, correlational survey research design. It investigated the relationship between the choices of physics subject at the elective level in high school with the PPD factors without manipulating them. Further logistic regression was used to predict their impact on the choice. A one- time interaction with the questionnaire was used to gather numerical data on the PPD factors.

2.2. Data collection

A research permit was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI). Subsequently, consent was sought from the county directors of education (CDE) in the respective counties, as well as from the principals of the participating schools. The questionnaires were administered over a period of one month. Each questionnaire took approximately 45 minutes to complete. A total of 378 students from public secondary schools in the counties of Isiolo and Nyeri participated in the study. These counties were chosen to reflect the diversity in socio-economic demographics across the country. Only form two (grade 10) learners were involved, because this is the stage when students select subjects for the remainder of their high school education. The sample and schools were selected using random sampling techniques.

Of the respondents, 49.2% (n=186) were male and 50.8% (n=192) were female, as shown in Table 1. This closely reflects the actual gender ratio in the population of secondary school students within the study area, comprising 10,993 males and 11,421 females CDE. In terms of age distribution, the majority (78%) of the respondents were between 14 and 17 years old. Additionally, 6.7% were below the age of 14, while 15.3% were above 18 years of age as shown in Table 1.

Table 1. Distribution of the sample size

Demographics		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

The sample size was determined using the sample size determination table in [34]. From a population of 22,414, a sample of 378 students was deemed sufficient. This meets the minimum requirement for logistic regression based on the thumb rule [35].

$$n = 100 + xi \quad (1)$$

Where n is the minimum sample size; *x* is the event per variable (EPV), taken as 50; and *i* is the number of independent variables; in this study, there are three. Thus, in this study, the minimum n is 250.

2.3. Data collection tools

The study used the difficult to learn physics scale (DiLP-S) by Ekici [24] .The tool uses a 4-point Likert-type scale ranging from "strongly disagree" to "strongly agree". The TF and the CF each had ten items, while the SA had seven. All the items were negatively worded. Table 2 indicates a sample of the items in each factor of PPD.

An aggregate mean of each individual item was used to represent each unidimensional construct. However, the constructs of TF, CF, and SA collectively formed the multidimensional construct of PPD. To ensure linguistic clarity and appropriateness, the questionnaires were piloted prior to the main study. The DiLPS employed in this research is considered valid, having been successfully used to measure similar constructs in previous studies, notably by Ekici [24]. Reliability of the instrument was assessed using Cronbach's alpha, yielding the following results: TF (α=0.892), CF (α=0.853), and SA (α=0.850). These values indicate a high level of internal consistency across all measured factors [36]. Scoring ranged from 4 to 1, with 4=strongly agree (negative perception), and 1=strongly disagree (positive perception). Descriptive statistics were used to evaluate students' perceptions, and the aggregate means were used to define constructs into four categories, as shown in Table 3.

Table 2. The DiLP-S blueprint

DiLP-S variable		Example questions
TF	1.	Teachers do not strive to make us like physics
	2.	Teachers do not ask questions encouraging us to learn during the physics lesson
CF	1.	There are too many concepts/ideas taught in the physics syllabus
	2.	There are too many formulae taught in the physics syllabus
SA	1.	Physics is not necessary for my future professional aspiration
	2.	Physics is not helpful in my life

Table 3. Data scoring and definition of each construct

PPD constructs	4	3	2	1
Teaching/learning experience as organized by the teacher (TF)	Excellent	Good	Poor	Very poor
CF	Very easy	Easy	Difficult	Very difficult
SA	Very exciting	Exciting	Boring	Very boring

2.4. Data analysis

Descriptive statistics included cross-tabulation of each factor to determine the distribution of each variable with choice of the physics subject. Chi-square test was used to check the strength of relationship of each variable with choice. The logistic regression analysis was used to model the probability of a learner's choice of physics subject at the elective level in high school. The model was (2):

$$logit\ (p) = \beta_0 + \beta_1(\chi_1) + \beta_2(\chi_2) + \beta_3(\chi_3) + \beta_3(\chi_3) \quad (2)$$

where: ρ=probability of the learner's choice of physics; χ_1, χ_2, χ_3=teacher, content, and student factors respectively; and β=regression coefficients. The dependent variable was binary: 1=yes (choosing physics) and 0=no. Goodness-of-fit tests, variance inflation factor (VIF) for multicollinearity, and predicted probabilities were used to evaluate the model.

3. RESULTS AND DISCUSSION

3.1. Relationship of variables with choice of physics in high school

3.1.1. Teachers' factors with choice of physics at high school

In the TF the role of teachers in organizing classroom teaching and learning experiences was examined. Results presented in Figure 2 indicate the frequency distribution within the aggregate mean of TF. The learners rated the teachers' role in curriculum delivery as excellent and good, with a combined total of 88.8 % among those choosing physics and 81.7% among those who did not. A chi-square $\chi^2(3)=6.682$, p=0.08, further confirmed that there was no statistically significant relationship between the teachers' role in classroom organization and students' choice of physics subject.

This is affirmed by the fact that over 80% of learners both those choosing and those not choosing physics, perceived the teachers as excellent and good. This implies that the teachers were able to connect with the learners through the way they organized teaching/ learning experiences. Thus, the teachers in this study met their primary role of mitigating PPD through their ability to vary their teaching/learning experiences [12], [37]. This could be attributed to the government concentrating on STEM teacher's in-service over the years which has enhanced uniform teaching standards. Therefore, the TF did not influence the choice of the subject. However, it was observed that the learners' choosing physics felt a stronger connection to the way teachers organized teaching/learning experiences as compared to those not choosing physics. This concurs with [12], [37], [38] who noted that the ability of the teachers to connect with the learner through the way they organize teaching and learning activities is the primary way of mitigating PPD.

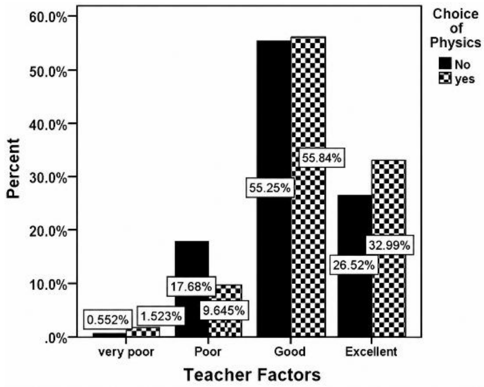

Figure 2. Teachers' factors distribution with choice of physics at high school

3.1.2. CF with choice of physics at high school

In the CF, physics concepts were generally perceived as difficult and theoretical, often requiring memorization were considered as the difficulty source. The frequency distribution was determined from the aggregate mean of each individual construct under the CF. Results in Figure 3 indicate that students who chose physics experienced the CF as either "very easy" or "easy", making up 74.6% of the group, while those who did not choose physics perceived the content as "difficult" and "very difficult", comprising 49.7%. This indicates a disparity in the perceived difficulty of the subject content between the two groups

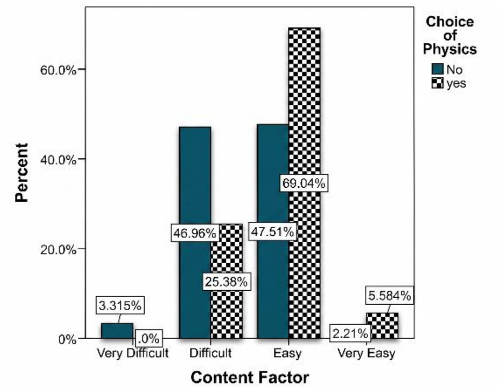

Figure 3. CF distribution with choice of physics at high school

A statistically significant relationship was found between CF and students' decisions to choose physics. Students who selected physics were more likely to perceive the subject content as easy or very easy, whereas a significantly lower proportion of those who did not choose physics shared this view. This supports [39] assertion that learners tend to avoid subjects they perceive as too difficult to succeed in. The perceived difficulty of physics content appears to relate closely to students' cognitive capabilities and the effort required to comprehend abstract concepts. This finding is consistent with previous studies [8], [9], [11], [23] which collectively emphasize that students' backgrounds significantly influence their familiarity with the content. Additionally, many physics topics presented before the subject selection phase were perceived as difficult, potentially discouraging learners from pursuing the subject further [39].

3.1.3. SA with choice of physics at high school

The frequency distribution was derived from the aggregate mean of each individual item within the SA construct. SA encompassed learners' perceptions of the importance and relevance of physics in their daily lives, their familiarity with physics-related terminology, peer interest in the subject, and their past academic performance in physics. As shown in Figure 4, both students who selected and those who did not select physics reported varying levels of SA. Among those who chose physics, 89.8% rated the subject as both "very exciting" and "exciting", compared to only 55.8% of those who did not choose the subject. This notable disparity indicates a significant variation in how SA is perceived between the two groups. The chi-square test result, $\chi^2(3)=73.976$, $p=0.00$, confirms a statistically significant relationship between SA and students' choice of physics.

The study found a statistically significant relationship between SA and students' choice of physics. A majority of students in both groups those who chose physics and those who did not acknowledged the subject's importance in everyday life, with more than half rating it as either "exciting" or "very exciting". However, the level of SA was notably higher among students who opted to study physics, confirming that SA is a key factor influencing subject selection. This variation in allure may be attributed to differences in students' individual aspirations, shaped by personal experiences, exposure to information from peers or teachers, and their understanding of physics concepts [40]. Additionally, students' self-perceptions of their academic abilities further contribute to how attractive they find the subject [33], [34]. These self-assessments often align with peer expectations and comparisons, influencing PPD and, ultimately, subject choice [40], [41].

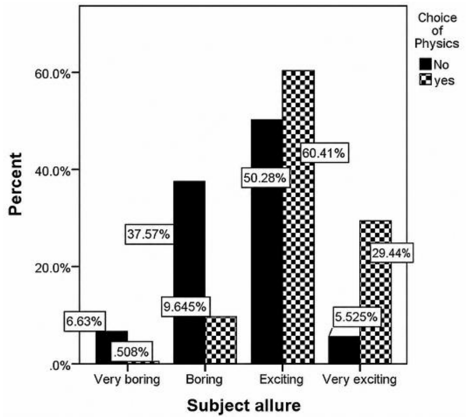

Figure 4. SA distribution with choice of physics at high school

3.2. Impact of PPD factors on the physics choice in high school

The logistic regression was used to investigate the influence of PPD factors on choosing physics as an elective in high school. Below is a detailed report on this part.

3.2.1. Logistic regression results

The logistic regression model assessed the teacher, content, and physics SA factors of PPD and their impact on the choice of the physics subject at the elective level in high school. The model form is (3):

$$logit\ (p) = \beta_0 + \beta_1(Teacher\ Factor) + \beta_2(content\ difficulty) + \beta_3(Subject\ allure) \quad (3)$$

where ρ represents the probability of a learner choosing physics at the elective level at high school. β represents regression coefficients. Table 4 indicates that the model showed that.

$$logit\ (Choice) = -5.614 + .255\ (Teacher\ Factor) + .389\ (content\ difficulty) + 1.445\ (Subject\ allure) \quad (4)$$

The test for the intercept (i.e., the constant in Table 4) $p<0.05$ suggests that this model can be applied to the data. The SA is the only predictive variable when the three are considered ($p<0.05$). From the coefficients; the analysis reveals that the TF, CF, and the SA are positive. This implies that as more learners perceive the content to be easy, the SA exciting, and encounter good to excellently organized teaching and learning experiences by the teachers, more learners choose physics at the elective level at high school [42].

Table 4. Summary of the model predicting learners' selection of physics at elective level in high school (logistic regression)

PPD factors	Coefficient (B)	Standard error	Wald	p-value	Exp (B)	95% CI for EXP (B)	
						Lower	Upper
TF	.255	.226	1.272	.259	1.290	.829	2.009
SA	1.445	.222	42.48	.000	4.244	2.748	6.554
CF	.389	.242	2.571	.109	1.475	.917	2.372
Constant	-5.614	1.067	27.68	.000	.004		

Note: N=378, at 95% CI, exponential co-efficient Exp (B) and exponential coefficient (B) are 'odds ratios'.

3.2.2. Overall evaluation of the model

Model assessment was performed by ensuring that the fundamental assumptions of logistic regression were met. The assumption of independence of observations was satisfied through the research design, as participants in the sampled population completed their questionnaires individually [43]. This section further assesses the model's goodness-of-fit, present's statistical tests of the predictors, and evaluates the regression results against the assessment of predicted probabilities.

a. Goodness-of-fit of the statistic

The model's goodness of fit was assessed using the Hosmer-Lemeshow test. The Hosmer- Lemeshow was $\chi^2(8)$ of 8.0 and $p>0.05$. This suggests a good fit of the data. This implies that the null hypothesis is tenable. In addition, the R^2 indices of Cox & Snell and Nagelkerke were used to define the goodness-of-fit. Table 5 reveals 20% of Cox & Snell and 27% of Nagelkerke as the variation in the choice of physics at the elective level at high school that the predictors can explain.

Table 5. Model validation and fit statistics

Test	Statistic	p-value
Hosmer-Lemeshow	7.22	.513
Cox & Snell R^2	0.20	
Nagelkerke R^2	0.27	

b. Statistical tests of predictors

The VIF was used to check for multicollinearity among the independent variables. This would ensure the coefficients' results are reliable. The results in Table 6 reveal that all the VIF values are below 5, and hence, multicollinearity is not of concern in this model [44].

Table 6. Multicollinearity check

Variable	VIF
TF	1.252
CF	1.457
SA	1.347

c. Assessment of predicted probabilities

The model's predictive power and impact of factors of PPD are further assessed, and receiver operating characteristics (ROC) curves were drawn. Figure 5 shows the ROC curves of TF, contentment factors, and SA. The results, as presented in Figure 5 and Table 7, confirm the logistic regression outcome that SA (area under curve (AUC)=0.730) is the most capable in the model to predict the choice of physics in form 2 against the CF (AUC=0.634) and TF (AUC=0.551) at moderate discriminating ability [45].

The impact of PPD on subject choice was assessed using logistic regression analysis. The model was found to be appropriate for the study, as the independent variables were not highly correlated, as confirmed by acceptable VIF values. Additionally, the model demonstrated strong predictive reliability, as evidenced by the assessment of predicted probabilities through ROC curves and AUC metrics. The model's goodness-of-fit further validated its suitability, supporting the tenability of the research hypothesis.

The logistic regression results showed positive coefficients for all three PPD factors TF, CF, and SA. This suggests that when students perceive the physics content as accessible, find the subject engaging, and experience well-structured teaching and learning environments, they are more likely to choose physics at the elective level in high school. These findings align with earlier observations from cross-tabulations and chi-square tests, reinforcing the directional relationships among the variables.

Importantly, when all three PPD factors were considered together, only SA emerged as a statistically significant predictor of physics choice. CF showed a weaker influence, followed by TF, which had the least impact. This contrasts with findings by Shrestha *et al*. [16], who identified content difficulty as the primary contributor to PPD, followed by SA. The current study provides critical insights for policymakers and educators seeking to promote physics, particularly in the context of STEM education. Enhancing the subject's appeal through both in-class and extracurricular activities that foster relevance and engagement can significantly increase student interest and enrollment in physics.

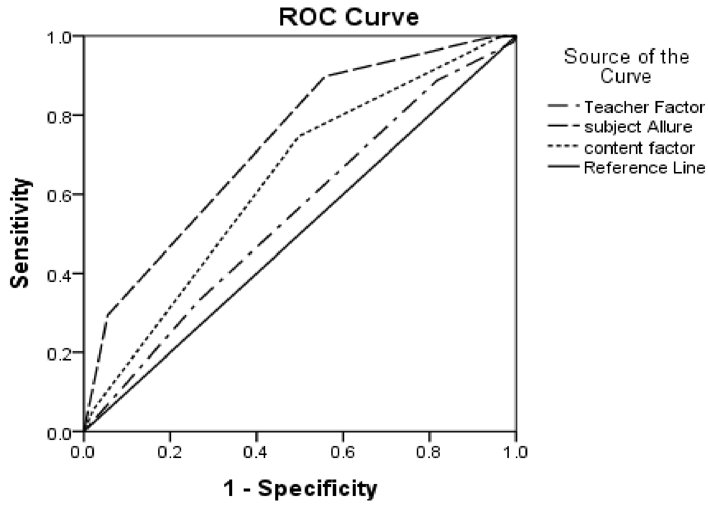

Figure 5. ROC curves for TF, CF, and SF

Table 7. AUC check

Test result variables	Area
CF	.634
SA	.730
TF	.551

4. CONCLUSION

This study underscores the critical influence of SA on students' decisions to take physics at the elective level in high school. Although content difficulty was shown to have some predictive relevance, it was students' interest, engagement, and personal connection with the subject that most strongly influenced their choices. TF, while essential for classroom delivery, did not significantly impact subject selection in this context. These findings highlight the need to make physics more engaging and personally meaningful. Strategies such as linking physics concepts to real-world applications, showcasing physics-related career opportunities, and fostering peer interest can enhance the subject's appeal. Policymakers and educators should focus on initiatives that strengthen the visibility and relevance of physics, particularly among underrepresented groups such as female students.

Future research should explore the impact of specific classroom and extracurricular interventions designed to enhance SA. Longitudinal studies could also investigate how students' perceptions evolve over time and influence long-term engagement with STEM disciplines. While this study is grounded in a context where curriculum and teacher training are standardized, limiting generalizability, its findings provide valuable guidance for national education strategies seeking to broaden participation in STEM subjects and promote inclusive educational opportunities.

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C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

Authors declare no conflicts of interest related to this study.

ETHICAL APPROVAL

A research permit (NACOSTI/P/21/8424) was obtained from the National Commission for Science, Technology and Innovation (NACOSTI). Respondent anonymity was maintained, and no personal identifiers.

DATA AVAILABILITY

The dataset generated and analyzed during this study is available from the corresponding author, [ERM], upon reasonable request.

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