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Research Article

Secondary school teachers' interest and self-efficacy in implementing STEM education in the science curriculum

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ABSTRACT

This study examines the role of Namibian secondary school science, technology, engineering and mathematics (STEM) teachers' interest in STEM education and self-efficacy in implementing STEM education in science education curricula. Furthermore, it aimed to distinguish male and female Namibian teachers' interests and self-efficacy regarding STEM education and investigate how different teaching subjects affect them. To achieve this goal, a survey was completed with (n=200) secondary school teachers, both males and females. Data were analyzed quantitatively using exploratory factor analysis and analyzed covariance. The results show that most teachers were highly interested and confident in implementing STEM subjects into science curricula. While Namibian teachers indicated a high level of interest, they also revealed a high lack of interest in STEM, implying that at least some teachers felt bored and meaningless in implementing STEM education. However, gender plays a significant role in teachers' negative self-efficacy, with male teachers being less confident than female teachers in implementing STEM education. Moreover, teachers in the present study have high positive and negative self-efficacy levels regarding implementing STEM education. Therefore, these findings highlight the need for a paradigm shift, especially in the Namibian science curricula, to promote STEM subjects and to improve science education. Potential implications from this research also suggest that teachers' participants benefit significantly from learning within a community by engaging in solutions to real-world problems.

Keywords: STEM education, interest, implementations, self-efficacy, gender

INTRODUCTION

The fundamental role of science in modern society is widely acknowledged (Killewald & Xie, 2013), and its importance in promoting technological innovation and sustaining economic growth is unquestioned. Thus, science, technology, engineering, and mathematics (STEM) education is a major focus of educational research (Boeve-De Pauw et al., 2022a, 2022b). STEM education cover two or more subjects (Hasanah, 2020; Margot & Kettler, 2019). However, there are few studies that investigate the extent of teachers' interest in teaching STEM (Chen et al., 2022), and those that do exist report a decline in teachers' interest (Nadelson et al., 2013) and self-efficacy in implementing STEM education; this is especially true for female teachers when compared to their male counterparts (Li & Singh, 2023; Sattari & Sandefur et al., 2019). As such, the USA, government agencies, and educational organizations are promoting the implementation of STEM curricula (Li et al., 2020).

For example, the Finnish university plug-in campus was established at a Namibian university to recommend software engineering education and coding fields (Shipepe et al., 2021). This was done to get a comprehensive review of STEM education and to tackle the complexity associated with STEM education.

There are debates over whether the four fields should be explored as a collective entity, resulting in definitions of STEM education that are unclear (Gonzalez & Kuenzi, 2012). STEM education is interdisciplinary, focusing on knowledge inquiry and application, higher-order thinking, critical thinking, and the problem-solving abilities of teachers and students (Bybee, 2013). Interest in STEM education may be individual or situational. Individual interest is a relatively stable and enduring personal predisposition towards a specific class of tasks, objects, and ideas. By contrast, situational interest is environmentally triggered and occurs when a particular situation attracts or demands a person 's attention (Hidi, 2006). For example, a new teaching method in science education may spark the interest of a teacher who is not generally interested in science education; that teacher will use that interest to develop the self-efficacy to be able to implement it.

Scholars have identified teachers' self-efficacy as a significant factor in teacher fulfilment, retention, and effectiveness, particularly in STEM subjects (Zee & Koomen, 2016). Self-efficacy can be referring to people's beliefs regarding their ability to perform STEM activity. According to El-Deghaidy (2015), some studies have considered the importance of interest and self-efficacy in STEM implementation. However, a recent study alluded that teachers' interest and self-efficacy in STEM education have declined over the years (Li & Singh, 2023). Moreover, schools with high poverty populations are more likely to lack quality K-12 STEM teachers (Kelley et al., 2020). Namibian teachers stipulated that they do not fully understand their roles when it comes to curriculum implementation (Katshuna & Shikalepo, 2023). Therefore, STEM education research needs careful thought to specified scope to tackle the complexity associated with it (Li et al., 2020). Additionally, many studies in Namibia focused on qualitative research (Shikongo, 2020), and to the best of our knowledge, more quantitative results are results quired to generalize the results to the entire population in terms of Namibian STEM education teachers' interest and self-efficacy implementation, and establish the number of classrooms, number teaching aids, media and resources related to significantly impact teachers implementation and students' learning (Komotolo et al., 2022). Therefore, the present study first investigates Namibian secondary school teachers' interest and self-efficacy in implementing STEM education into the curriculum, then examines the differences between male and female teachers. Finally, the study compares teachers' interest and self-efficacy in various STEM subjects.

LITERATURE REVIEW

Implementing STEM education is linked to integrating each of its four subject areas to solve real-world problems (Guzey et al., 2016) in educational settings. Furthermore, curricula focusing on single disciplines may become progressively more multi-, inter-, and transdisciplinary when STEM education is implemented (Roehrig et al., 2021). In interdisciplinary subjects, each educational issue is identified in the curriculum's main topic (Sulaeman et al., 2022), but interdisciplinary subjects are so closely interrelated that it may be challenging to distinguish one subject from another (Moore et al., 2014), and transdisciplinary approaches connect STEM subjects to social and environmental topics (Roehrig et al., 2021). However, this does not mean that one discipline is superior to another; rather, different fields and issues are appropriate for different applications. In recent years, the Namibian curriculum has included new STEM-related subjects in secondary schools, including computer science, design, and technology (Namibian Ministry of Education [MoE], 2016). These changes happened because computers were introduced to school library for students to make use of them and allow students to do practical work on the school ground, which involve educational robotics (Shipepe et al., 2022). STEM can encourage teachers and students to be acquitted with the skills necessary for designing, developing, utilizing technology and solve problems (Dailey et al., 2018).

STEM education brings mathematics and science concepts, often taught in a vacuum to life by encouraging teachers to address real-world problems (Margot & Kettler, 2019). According to Dong et al. (2020), teachers have a moderate to high level of interest in implementing STEM courses. For example, teachers may know that the formula for table salt is sodium chloride but may not intuitively connect that formula to the salt they use in their kitchens. A study conducted by El-Deghaidy and Mansour (2015) report that in Saudi Arabia, mathenatics and science are usually taught separately. Although, this is similar in Namibia, the revised curriculum has allowed students to experience real-life practical, which are integrated (Anyolo et al., 2018). Low levels of teacher interest in implementing STEM education are associated with insufficient classroom time allocated to implementing STEM education rather than training (Ismail et al., 2019). Some stereotypes around STEM education categorize teachers who opt to teach STEM subjects as lacking a sense of style (Luo et al., 2021). For example, STEM subjects are often perceived as authoritative and competitive and they may be more aligned with men's inclinations than women (Diekman et al., 2015).

Female graduates get fewer jobs than their male peers when they graduate with STEM university degrees, which ultimately influences teachers' self-efficacy (Filippi & Agarwal, 2017). As a result, female teachers lack interest in STEM education due to prioritizing tensions between career and family (Sattari & Sandefur et al., 2019). Some studies reported that female teachers have more positive self-efficacy than male teachers (Al Bataineh & Anderson, 2015). Teachers with high positive self-efficacy see difficulties as challenges, which can be overcome with determined effort and opportunities to gain the necessary knowledge and skills (Kelley et al., 2020), in contrast to a study conducted in Vietnam, which indicated that negative self-efficacy impeded teachers from effectively implementing STEM teaching in high schools (Le et al., 2021). In any case, reduced or even negative self-efficacy among teachers has led STEM researchers to embark on professional development courses to improve teachers' confidence (Christian et al., 2021).

Teachers' self-efficacy can correlate positively with a commitment to teaching. According to Lee et al. (2019), male teachers display a higher level of self-efficacy in STEM education than female teachers. Similarly, Hill et al. (2010) found that once students reach the university level, females are far less likely than males to pursue a STEM major, which results in large numbers of males outperforming female graduates in STEM courses because male teachers are mathematically superior and innately better suited to STEM fields.

Teachers' negative self-efficacy prevents them from successfully implementing STEM (Le et al., 2021); they often consider themselves unprepared to implement STEM education, even when they are interested in introducing it (Shernoff et al., 2017). Al Bataineh and Anderson (2015) noted that female teachers have more positive self-efficacy than male teachers. Therefore, the key to training good science teachers lies in fostering teachers' positive beliefs about science and their ability to teach it. However, a negative link exists between classroom activities such as practical work and workload on the one hand and self-efficacy on the other (Klassen & Chiu, 2011). This training can also extend to gender issues related to teacher self-efficacy in STEM education.

Female teachers generally involve STEM approaches less frequently than male teachers (Yang & Gao, 2021) because males are more interested in the application and practice of science and more likely to study and pursue careers in science (Nimmesgern, 2016). In fact, some researchers have suggested that male teachers are biologically inclined to outperform female teachers in mathematical tasks, especially spatial representation tasks; this better performance influences an overrepresentation of men in STEM professions (Wegemer & Eccles, 2019). According to a study conducted among Ghanaian teachers, male teachers surpass female teachers in mathematical intelligence (Budu et al., 2022). Conversely, Wardat et al. (2022) reported that male and female teachers have similar perceptions and opinions about the practice and instruction of mathematics and science. Thus, teacher self-efficacy is positively associated with commitment to and comfort with teaching STEM materials; teachers with high self-efficacy tend to be more willing to try to provide STEM education (Zee & Koomen, 2016). Unsal et al. (2016) stated that teachers with positive self-efficacy in mathematics are more flexible when teaching. Meanwhile, there are extreme differences in the number of males and females who pursue STEM degrees, with males outnumbering females in most of these fields (National Science Foundation [NSF], 2017). There is a significant difference in how teachers view STEM subjects (Ertl et al., 2019; Luo et al., 2021). Variations in subject choice for one or both majors in STEM education result when teachers feel underprepared to teach science (Fitzgerald & Smith, 2016). Even though it is imperative to continue encouraging females to study STEM fields and pursue STEM careers, it is equally important to develop policy measures to address males' performance at the tertiary level (Wrigley-Asante et al., 2023).

Technology teachers tend to demonstrate higher self-efficacy in STEM (Lee et al., 2019) because robotics have become popular in schools, bringing computational thinking skills into STEM education and sustaining scientific practice (Weintrop et al., 2016). Additionally, teachers have high self-efficacy and confidence in performing specific tasks that require integrating information communication technology (ICT) into teaching practice (Šabić et al., 2022). Hartell et al. (2015) concluded that teachers trained explicitly in technology and supported by their teacher training in that regard have positive self-efficacy and are more likely to teach in a way aligned with curricula. However, the nature of the Namibian curriculum, which requires teachers to have two majors (Mushaandja et al., 2013), negative self-efficacy and disinterest in STEM are essentially bound to occur, as teachers may receive a lower grade in one STEM subject and a higher one in another (Mushaandja et al., 2013; Sichombe, 2018). Moreover, some teachers are simply less interested in STEM subjects (Thi To Khuyen et al., 2020).

In a survey, Jordan and Carden (2017) found that females' self-efficacy shows lower academic confidence scores than males, which can affect their perseverance in and satisfaction with engineering majors. Lee et al. (2019) reported that teachers with higher self-efficacy in engineering design tended not to be happy when teaching STEM in class. Watt et al. (2017) revealed that subject groups such as mathematics, physics, chemistry, and biology show differences in gendered processes of influence by prior mathematical performance. Technology teachers performed better than mathematics and science teachers (Lee et al., 2019). It has been reported that female science and mathematics teachers might influence female students to graduate with a STEM degree (Vooren et al., 2022). However, even though Kelley et al. (2020) found that self-efficacy affects the goals that individuals set for their other studies, those authors found no gender differences in self-efficacy in mathematics or computer science.

Research Aim & Questions

STEM education subjects are often considered difficult, negatively impacting teachers' psychological ability to provide those lessons (Amadhila & Guest, 2022). For example, according to Mashebe and Zulu (2022), STEM education of female teachers in Namibia still needs to catch up to that of male teachers; this trend has lingered from the days of apartheid, where the availability of education was available based on a student's race, gender, and ethnic background. Even today, only a few female students pursue STEM subjects (Mashebe & Zulu, 2022). Namibian Institute of Science and Technology reports that STEM courses have lower enrolment rates than other fields and twice as many males as female students enroll in STEM courses (Namibian University of Science and Technology [NUST], 2016). Furthermore, overall enrolment in STEM courses has decreased in recent years along with teacher interest (Ali & Shubra, 2010) and self-efficacy regarding teaching science (Thomas & Watters, 2015). To further explore this problem, we pose the following research questions:

RQ1. To what extent are Namibian secondary school STEM teachers interested in STEM education? Also, to what extent do Namibian STEM teachers have self-efficacy to implement STEM education in science education curricula?

RQ2. To what extent do male and female Namibian teachers' interests and self-efficacy regarding STEM education differ?

RQ3. To what extent do different teaching subjects affect Namibian teachers' interest and self-efficacy?

METHODS

Procedure & Sample

Data were collected in the form of a survey administered in spring 2022. Permission to carry out the study was granted based on the ethical guidelines of the Finnish National Board on Research Integrity (2019) and the Namibian Executive Director of Education. The researchers sent the survey link to the principals of 30 schools in the Oshana Region in the northern part of the country; they were asked to forward the link to teachers of STEM subjects who were willing to participate. The participants filled out the online survey individually at their convenience. The survey took 15-20 minutes, and participants provided no identifying information. As shown in **Table 1**, a total of n=200 secondary school teachers participated in the study. **Table 1** also lists participants' demographic data, including gender, primary subject of instruction, and years of teaching experience.

Table 1. Demographic data of participating secondary school teachers

Characteristic		Frequency (%)
Gender	Male	122 (61)
	Female	78 (39)
Main subject taught	Science	66 (33) (M: 45, F: 21)
	Mathematics	77 (38.5) (M: 42, F: 35)
	Engineering	41 (20.5) (M: 28, F: 13)
	Technology	16 (8) (M: 7, F: 9)
Years of teaching experience	One	9 (4.5)
	Two	49 (24.5)
	Three or more	142 (71)

Measurement

The present study reports on measurements of teachers' interest and self-efficacy in implementing STEM education in science education. The online questionnaire measuring teacher interest consisted of 20 items; the questionnaire measuring teacher self-efficacy consisted of 14 items. The items on teacher interest were adapted from a previous survey (Tyler-Wood et al., 2010) and addressed four subjects (science, mathematics, engineering, and technology); five statements were used to measure teachers' level of interest in each subject (see **Appendix A**). A survey developed by Roberts and Henson (2000) was used to measure self-efficacy. This survey, which used positive and negative scales to measure self-efficacy, initially comprised 16 statements, but only 14 were included in the present study (see **Appendix B**); the other two items were deemed irrelevant to the Namibian context. This instrument uses positive and negative scales to measure self-efficacy (see **Appendix B**). The questionnaire used a five-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). Participants were chosen using convenience sampling, a non-probability sampling approach that targets members of a population meeting certain criteria. In the present study, we targeted secondary school teachers in a single region of Namibia who taught STEM subjects and were easily accessible, willing, and available to complete the survey. Participants were assured that their responses would remain anonymous. This sampling method is necessary to obtain sufficiently robust results regarding secondary school teachers' interest in and self-efficacy at implementing STEM education.

Analysis

To measure the validity and reliability of our survey, we conducted Cronbach's alpha (α) tests and carried out exploratory factor analysis (EFA) using principal axis factoring and varimax rotation. After confirming the tool 's validity and reliability, we created a mean variable for each factor. We examined the effects of gender and teaching subjects on each construct using a t-test and a one-way analysis of variance (ANOVA). Since one of the first steps of both a t-test and one-way ANOVA is to test the assumption of normality, we also assessed the normal distribution of each factor before conducting these tests. The data were analyzed using the statistical package for social sciences (SPSS) 25.0.

RESULTS

Measurement Validation

As shown in **Table 2**, EFA results of the interest scale showed that the measurement items loaded onto the expected factors and that there were no significant loadings onto other factors. Cronbach's alpha (α) for all factors is excellent: factor 1 (STEM disinterest)=.941; factor 2 (mathematics and engineering)=.880; factor 3 (science)=.836; factor 4 (technology)=.890. We also measured the normality of each factor. The results for interest-related factors were, as follows: factor 1 (STEM disinterest): skewness=-.993 (standard error [SE]=.172), kurtosis=-.227, (SE=.342); factor 2 (mathematics & engineering): factor skewness=-.611 (SE=.172), kurtosis=.672 (SE=.342); factor 3 (science): factor skewness=-.634 (SE=.172), kurtosis=.352 (SE=.342); factor 4 (technology): factor skewness=-.481 (SE=.172), kurtosis=.237, (SE=.342). These results confirm the normal distribution of each factor. However, the mathematics and engineering scales were separated since this study focuses on different kinds of STEM subjects; in this scale, three items measured mathematics, and three items

Table 2. EFA results for interest scale

Item	Factor loading			
	1	2	3	4
STEM disinterest1	.847			
STEM disinterest2	.829			
STEM disinterest3	.819			
STEM disinterest4	.818			
STEM disinterest5	.808			
STEM disinterest6	.808			
STEM disinterest7	.798			
STEM disinterest8	.767			
Mathematics1		.792		
Mathematics2		.790		
Mathematics3		.747		
Engineering1		.672		
Engineering2		.635		
Engineering3		.614		
Science1			.803	
Science2			.815	
Science3			.667	
Technology1				.768
Technology2				.670
Technology3				.605

Table 3. EFA results for self-efficacy scale

Item	Factor loadings		
	1	2	3
Negative1	.826		
Negative2	.693		
Negative3	.669		
Negative4	.659		
Negative5	.620		
Negative6	.604		
Negative7	.535		
Positive1		.709	
Positive2		.649	
Positive3		.582	
Positive4		.576	
Positive5		.553	
Positive6			.563
Positive7			.654

measured engineering. Cronbach's alpha (α) values for the factors of mathematics and engineering were satisfactory (.880 and .833, respectively).

We also conducted an EFA for the self-efficacy scale; the results showed that items were loaded onto three factors. In line with previous studies, the first factor was related to the positive scale of self-efficacy; the second factor was related to the negative self-efficacy scale, while the third was related to part of the negative scale.

However, as two items (P6 & P7) were loaded onto two different factors, we decided to remove those items from the subsequent analyses. Thus, seven items were included in the negative self-efficacy scale, and five items were included in the positive self-efficacy scale. Cronbach' 's alpha for each factor was excellent: factor 1 (negative scale)=.869; factor 2 (positive scale)=.855. The normality of each construct was also tested; the results were, as follows: negative scale: skewness=-.912 (SE=.172), kurtosis=.407 (SE=.342); positive scale: skewness=-.463 (SE=.172), kurtosis=.439 (SE=.342). These results demonstrate that the reliability and validity of the two self-efficacy scales are satisfactory, while the normality test indicates that the data were normally distributed (**Table 3**).

Table 4. Means & standard deviations of secondary school teachers' interest in & self-efficacy at implementing STEM education in science curricula

Factors		Mean	Standard deviation
Interest	STEM interest	3.16	1.07
	Science	3.87	0.82
	Technology	3.75	0.89
	Engineering	3.65	0.85
	Mathematics	3.73	0.91
Self-efficacy	Negative scale	3.31	0.79
	Positive scale	3.62	0.72

Table 5. Effects of gender on teacher interest & self-efficacy

Scale	Sub-category	Male: M (SD)	Female: M (SD)	F
Interest	STEM interest	3.22 (.99)	3.05 (.77)	1.21
	Science	3.82 (.83)	3.97 (.82)	1.58
	Technology	3.75 (.84)	3.75 (.96)	0.00
	Engineering	3.71 (.91)	3.75 (.93)	0.09
	Mathematics	3.59 (.85)	3.76 (.83)	2.10
Self-efficacy	Negative scale	3.43 (.73)	3.13 (.86)	6.90*
	Positive scale	3.65 (66)	3.59 (.82)	.32

Note. M: Mean & SD: Standard deviation

Table 6. Effect of subject taught on teacher interest & self-efficacy

Scale	Sub-category	Science: M (SD)	Technology: M (SD)	Engineering: M (SD)	Mathematics: M (SD)	F
Interest	STEM interest	3.02 (1.10)[a]	3.63 (.90)	3.62 (.63)[a & b]	2.93 (1.17)[b]	5.36*
	Science	3.82 (.87)	3.67 (.75)	3.74 (.82)	3.69 (1.02)	0.39
	Technology	3.47 (.88)	3.67 (.62)	3.80 (.67)	3.71 (.93)	1.62
	Engineering	3.88 (.79)	4.27 (.55)	3.86 (.69)	3.79 (.94)	1.52
	Mathematics	3.79 (.93)	3.56 (.81)	3.83 (.71)	3.72 (.95)	0.42
Self-efficacy	Negative scale	3.36 (.81)	3.68 (.69)[c & d]	3.56 (.47)[b & c]	3.07 (.87)[b & d]	5.19*
	Positive scale	3.65 (.76)	3.89 (.57)	3.60 (.59)	3.56 (.77)	0.99

Note. M: Mean; SD: Standard deviation; *p<.05; **p<.01; ***p<.001; [a]Significant difference between science & engineering; & [b]Significant difference

RQ1. Teachers' Interest & Self-Efficacy in Implementing STEM Education

The results shown in **Table 4**, indicate that Namibian STEM teachers are very interested in implementing STEM education, as the mean values for all STEM subjects are all three or greater. Teachers of STEM subjects reported the highest interest in science and the lowest interest in engineering. However, STEM disinterest factor was also greater than three, indicating that to some extent, Namibian teachers also lack interest in STEM education. The results also indicate that teachers had high levels of positive self-efficacy for implementing STEM education.

Notably, however, participants also revealed high levels of negative self-efficacy, although this value was lower than that of the positive scale. As these results conflict, one possible explanation for this finding is addressed in the discussion section.

RQ2. Effect of Gender on Teachers' Interest & Self-Efficacy for Implementing STEM Education

As shown in **Table 5**, there was no gender difference in STEM interest. However, we found a significant difference between male and female teachers on the negative self-efficacy scale, as male teachers had higher mean values than female teachers on that scale, meaning that female Namibian STEM teachers have higher self-efficacy regarding STEM education than their male counterparts. By contrast, male and female STEM teachers had similar interest levels in STEM education.

RQ3. Effect of Teaching Different Subjects on Teacher Interest & Self-Efficacy

Table 6 shows the statistical differences between teachers' interest in and self-efficacy regarding STEM education based on the subject taught. Engineering teachers indicated a higher level of disinterest in STEM education than science and mathematics teachers. Furthermore, engineering and technology teachers reported higher levels of negative self-efficacy than mathematics teachers, while no difference in self-efficacy was found between science and other STEM teachers. Overall, these results imply that engineering and technology teachers may have lower levels of interest in and lower self-efficacy in implementing STEM education than science and mathematics teachers.

We also analyzed covariance (ANCOVA) to confirm the results for **RQ3**; we did so for two reasons: First, we found a gender difference in the negative self-efficacy scale. Second, the gender ratios in different groups of STEM teachers varied (**Table 2**). Thus, we wanted to confirm that the difference in negative self-efficacy based on subject taught was still present after we controlled for any effects of gender. The results of the ANCOVA show that subject taught still significantly impacted negative self-efficacy ($F[3, 195]=5.65$, $p=.001$) after we controlled for the effect of genders ($F[1, 195]=7.09$, $p=.008$). This finding confirms that the subject taught by Namibian STEM teachers impacts their self-efficacy at implementing STEM education.

DISCUSSION & CONCLUSIONS

This study aimed to achieve three objectives. First, it has analyzed Namibian secondary school teachers' interest and self-efficacy in implementing STEM education in science curricula. Second, it investigated differences in secondary school teachers' interests and self-efficacy based on gender and STEM subjects. Finally, it explored the impact of the subject taught on teacher interests and self-efficacy among Namibian secondary school teachers. The study's findings highlight the high level of teachers' interest in implementing STEM education, which signifies that teachers are fascinated and excited about STEM implementation, in line with the study of Dong et al. (2020), who reported that teachers have a moderately to high level of interest STEM courses because they used their technical, engineering, and mathematical backgrounds to explain scientific problems in STEM education. Therefore, STEM projects are necessary to encourage and support teachers' interests (Nguyen et al., 2020). Remarkably, while Namibian teachers in our sample indicated a high level of interest, they also revealed a high lack of interest in STEM, implying that at least some teachers felt bored and meaningless in implementing STEM education. The reason for disinterest is not training in STEM education but too little classroom time, in line with the study of (Ismail et al. 2019; Zimba et al., 2018), who found that too little classroom time was allocated to implementing STEM education. To combat teachers' disinterest in STEM education, Namibian MoE should adjust the curriculum to increase STEM-related classroom time for teachers (Duarte et al., 2018).

On the other hand, in contrast to previous theories and studies that found teachers to have negative self-efficacy when implementing STEM (Le et al., 2021), the teachers have both high positive and negative self-efficacy levels regarding the implementation of STEM education. This is because Namibian teachers are trained to teach two major subjects (Katshuna & Shikalepo, 2023). For instance, mathematics and science. Katshuna and Shikalepo (2023) argued teachers need more knowledge and professional development to implement and execute each subject due to the challenges they experience in each subject, which affects their interest and self-efficacy. High positive self-efficacy implied that teachers felt comfortable improvising during STEM education and knew the steps necessary to teach STEM education concepts effectively, which is in line with the study of Kelley et al. (2020), who suggested that teachers with high positive self-efficacy see difficulties as challenges, which can be overcome by sharing their failures in their work, including STEM contexts. Thus, it may be necessary to find creative instructional practices to improve STEM implementation through professional development (Shernoff et al., 2017). Contrary to high positive self-efficacy, high negative self-efficacy suggests that teachers find STEM challenging and feel anxious when teaching STEM education content that they have not previously taught, which is in line with the study of Le et al. (2021), who reported that teachers' negative self-efficacy prevents them from successfully implementing STEM content because it may be too complex for some teachers; presumably, this causes them to have both positive and negative self-efficacy depending on which STEM subjects they teach. These findings might be affected by comparatively recent introduction of STEM education in Namibia (Tikly, 2018). Consequently, teachers should be involved in courses to improve their confidence and self-efficacy in STEM (Christian et al., 2021).

The differences in male and females teachers' ability to implement STEM revealed in the present study may not be surprising, and the results show that male teachers are more committed to implementing STEM education than female teachers, resulting in negative self-efficacy among the latter group; this is because STEM subjects are generally considered male-oriented (NSF, 2017). This contradicts the results in Al Bataineh and Anderson (2015), who found female teachers to have more positive self-efficacy than male teachers because female teachers tend to be more comfortable in improvising during STEM education, thus increasing their ability to teach STEM education concepts. Additionally, STEM needs to be developed and implemented in the education curriculum to honed teachers' process (Ratnasari & Hendriyani, 2023). As a result, educational directors should offer teachers mentoring programs focussed on STEM-based instruction (Syafril et al., 2021) and training to enhance their application in STEM (Nguyen et al., 2020).

It is not that the subject matter in STEM is boring–let alone meaningless–but that teachers have less interest in it, as our study revealed a significant difference in STEM disinterest between science, and engineering teachers, supporting Jordan and Carden's (2017) claim that teachers' lower interest and academic confidence scores affect their perseverance at and satisfaction with engineering majors. To overcome teachers' disinterest, they should identify and employ appropriate resources that do pique their interest (Estapa & Tank, 2017). Furthermore, our findings regarding STEM disinterest highlight that STEM education draws on content and skills from mathematics and engineering, in contrast with Christian et al. (2021), who identified engineering subjects as a powerful tool in extending the critical thinking and problem-solving skills that elevate teachers' interest. Therefore, teachers should be encouraged to include appropriate instructional materials from the engineering field to spark their interest (Zalmon & George, 2018). Moreover, a difference in negative self-efficacy between engineering and technology teachers was observed in this study, which implies that teachers feel that they do not have the necessary skills to teach STEM education and thus find STEM a complex subject. As STEM skills overlap with the 21st century education (Hamdu et al., 2020). This result runs counter to Šabić et al.'s (2022) study, which reported that teachers who are skilled in performing tasks requiring the frequent integration of ICT into their teaching practice have greater self-efficacy. Thus, preparation programs that focus on teaching skills are necessary to increase teachers' self-efficacy and improve the quality and amount of instruction in the classroom (Naidoo & Naidoo, 2023).

Teachers may find it challenging to explain to students why STEM education works, which generally results in their ineffectiveness in teaching STEM. Negative self-efficacy of technology and mathematics teachers in this study contradicts findings of Unsal et al. (2016), who reported that teachers with self-efficacy in mathematics were more flexible while teaching, whereas Hartell et al. (2015) concluded that teachers trained explicitly in technology and supported in that regard by their teacher training have positive self-efficacy and are more likely to teach in a way aligned with curricula. Thus, negative self-efficacy can be mitigated by including improved preparation, better teaching strategies, and more tailored pedagogical approaches during teacher training at university and STEM teachers must include performance tasks, which are important and relevant context of students (Rogayan Jr et al., 2021). To sum up, negative self-efficacy and disinterest in STEM may occur in Namibian context because teachers may occasionally receive a low grade in one STEM subject and a high grade in another, yet, as STEM majors, they are required to teach both subjects (Sichombe, 2018). This may cause teachers to have negative self-efficacy in one major subject and positive self-efficacy in another. STEM instruction in education could be improved if teachers received bottom line that they want and need: practical in-service activities that address genuine classroom needs and make them better teachers (Heba et al., 2017).

Limitations

This study examined Namibian teachers' level of interest and self-efficacy in incorporating STEM education into the science curriculum. However, it is essential to note that the study has some limitations. This study only focused on secondary school teachers, excluding students taking part in STEM subjects. Therefore, future studies should include students to understand their role in affecting teachers' interest and self-efficacy in STEM implementation. Furthermore, researchers should also collect data from primary school teachers since STEM subjects are also taught to some extent at this level. Despite these limitations, this study is valuable. Its findings can set the stage for future in-service STEM educational training research. They will help teachers recognize the importance of considering multiple STEM subjects when they teach STEM-related topics. Finally, policymakers should also consider the possibility that male STEM teachers have more negative self-efficacy than female teachers regarding STEM implementation

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APPENDIX A

Table A1. Secondary school teachers' interest in implementing STEM education in science education (n=200)

Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
To me, science is					
Fascinating	5	13	61	73	48
Appealing	4	14	40	89	53
Exciting	3	8	38	88	66
Meaningless	41	13	32	87	27
Boring	38	20	48	71	23
To me, mathematics is					
Fascinating	11	20	49	83	37
Appealing	5	21	38	88	48
Exciting	5	12	43	89	51
Meaningless	41	10	44	76	29
Boring	38	19	50	75	18
To me, engineering is					
Fascinating	5	30	55	80	30
Appealing	4	19	54	84	39
Exciting	2	19	52	77	50
Meaningless	33	11	54	71	31
Boring	28	25	62	64	21
To me, technology is					
Fascinating	4	26	57	70	41
Appealing	6	10	56	76	52
Exciting	4	9	50	86	51
Meaningless	38	9	44	83	26
Boring	38	17	72	60	13

APPENDIX B

Table B1. Secondary school teachers' self-efficacy for implementing STEM education in science curricula (n=200)

Statements	SD	D	N	A	SA
I do not feel I have the necessary skills to teach STEM education.	20	16	60	84	20
I am usually able to answer students' STEM questions.	1	15	55	92	37
Given a choice, I would not invite the dean of students to evaluate my STEM education.	16	21	64	81	18
I feel comfortable improvising during STEM education.	4	14	67	85	30
After I have taught STEM education concept once, I feel confident teaching it again.	3	22	56	80	39
I find STEM a difficult subject to teach.	16	25	54	84	21
I know the steps necessary to teach STEM education concepts effectively.	3	21	65	89	22
I find it difficult to explain to students why STEM education works.	15	35	62	76	12
I am continually finding better ways to teach STEM education.	4	20	62	85	29
I am ineffective at teaching STEM.	22	23	47	86	22
I understand STEM education-related concepts well enough to teach effectively.	3	18	61	88	30
I know how to make students' interest in STEM education.	4	24	60	89	23
I feel anxious when teaching STEM education content that I have not taught before.	11	28	55	88	18
I wish I had a better understanding of the STEM concepts I teach.	11	24	73	72	20

Note. SD: Strongly disagree; D: Disagree; N: Neutral; A: Agree; & SA: Strongly agree

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