Facilitating factors encouraging girl learners to choose science, technology, engineering, and mathematical subjects and related careers: A South African case study

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ABSTRACT

In recent years, there has been a drive to recruit more women into science, technology, engineering, and mathematics (STEM) careers. However, a perceived lack of interest by girl learners in STEM subjects and careers presents a challenge. Therefore, the purpose of this study was to investigate the reasons that encourage high school girls to choose STEM subjects and careers. A qualitative design that adopted the case study approach using the interpretivist paradigm was chosen for this study. The data were collected using a focus group with a novel sample of girls taking technical subjects at a technical high school in a rural area. The study identified four facilitating factors that steer girl learners towards choosing STEM subjects and STEM-related careers. These factors were primary school experience, parental influence, prosperity through employment and entrepreneurial opportunities, breaking stereotypes, and being a role model. The insights gained from this study could be beneficial to the government, businesses, social activists, schools, teachers, and other relevant stakeholders in encouraging girl learners to choose STEM-related and related careers.

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Introduction

Governments, corporations, and social activists have launched a variety of efforts over the past 30 years with the goal of boosting the proportion of women enrolled in STEM degree programs and careers. According to Charles (2017), the motivation behind these programs is to solve the labor shortage in the technical and scientific domains as well as to give women access to secure, high-paying employment. The requests to boost female participation in STEM programs go beyond this, too, and one of the most important ones is the radical and deliberate inclusion of women in fields where men predominate.

The government and other stakeholders may be able to increase access and improve the number of girls choosing technical subjects and related careers by having a better understanding of why they do so, particularly in rural areas, which have low socioeconomic environments and present difficulties for STEM success (Murphy, 2020). This request is supported by the African Agenda 2063 aspirations, which call for development to be people-driven, rely on the potential of Africans, particularly their women and youth, and care for children, as well as the achievement of educated citizens and a skills revolution supported by science, technology, and innovation (African Union, 2013). It is important to take into account the variables that influence each person's educational and employment choices as the gender gap in STEM career fields remains (Blotnicky, Franz-Odendaal, French, & Joy, 2018).

The reasons why under-represented adolescent girls choose technical subjects and related career fields from the perspective of students who are prepared to contribute to STEM fields is a topic of limited research, particularly qualitative research (Grossman & Porche, 2014; Pinder & Blackwell, 2014). Additionally, the focus of this study's environment is technology education since (Yata, 2014). Additionally, the focus of this study's environment is technology education since (Yata, 2014).
STEM education research frequently emphasizes a preference for science and mathematics over technology and engineering. Therefore, the goal of this study was to look at the motivating elements that influence high school girls' decision to major in technical fields and pursue professions in those fields.

The next section is devoted to examining the research literature in order to grasp the theory and other researchers' results on the topic after introducing the topic for discussion. The theoretical framework that underlies this study is also covered in the section on literature reviews. In the third section, a discussion of the methods used for data collecting and analysis is provided. The study's analysis and conclusions are followed by discussions and recommendations. This paper concludes with essential ideas, suggestions, limitations, and directions for future research.

**Literature Review**

Research points to several factors affecting subject choice (Ardura & Pérez-Bitrián, 2018). Students' choice of subjects is heavily influenced by the quality of STEM education, particularly the teacher's role. According to Javed (2018), a teacher’s character, attitude and opinions are held in high regard by learners. Teachers, therefore, need to change their beliefs and attitudes about STEM, which could result not only in better quality instruction and learning (Margot & Kettler, 2019) but in the their sphere of influence for learner school subject and career choice. The changes in belief and attitudes, and better-quality instruction and learning therefore create positive learners’ perceptions and increase their interest in STEM (Affouneh, Salha, Burgos, Khlaif, Saifi, Mater & Odeh, 2020). Palmer, Burke, and Aubusson (2017) found that enjoyment, interest, ability, and perceived need in their future study or career plans were the major factors when choosing or rejecting subjects as compared to peers, teachers and parents.

Social support has been found to be an influencing factor on the choice of career and contributes to a positive perception of the career (Buday, Stake, & Peterson, 2012). Science success and the decision to continue studying science are related to the socioeconomic status of a learner and their school (Shavit & Müler, 2000). Schools in rural areas unlike those in metropolitan areas often have limited subject choice (Sullivan, Perry, & McConney, 2013). For example, Ainley, Kos, and Nicholas (2008) found that well-educated, wealthy, and English-speaking parents have a greater tendency to encourage their children to study science. However, according to Mujtaba et al., (2018) students from disadvantaged backgrounds are more inclined to select science if they believed it will help them in advancing their career aspirations. Thus, take them out of their unfortunate poverty context lives. Moreover, the perceived value of science has been found to be positively associated with the scientific career aspirations of learners (Sheldrake, Mujtaba & Reiss, 2017). Studies suggest that learners’ beliefs about the outcomes of science selection are key determinants of learners’ choice of science, and they are affected by the influential role of parents in the formation of these beliefs (Wang & Degol, 2013).

Self-efficacy refers to individuals’ confidence in their abilities in handling challenges, tasks and contexts and how this impact on their choices (Bandura, 2006) which results in a persistent interest in an activity (Lent, Brown & Hackett, 2000). Therefore, self-efficacy plays a pivotal role in the development of self-confidence and motivation (Maiorca, Roberts, Jackson, Bush, Delaney, Mohr-Schroeder & Soledad, 2021; Avci, Tösten, & Çelik, 2019). Girl learners have been found to have lower confidence in their mathematical abilities (Else-Quest, Hyde & Linn, 2010; Thomson, De Bortoli & Buckley, 2013). However, there was no difference in previous academic performance in relation to boys (Pomerantz, Altermatt & Saxon, 2002). The low levels of self-efficacy in female STEM learners and the results this has on their persistence with STEM subjects has been reported (Fisher, Thompson & Brookes, 2020). For example, A study by Tellhed, Bäckström, and Björklund (2017) found that women’s lower self-efficacy for STEM careers was strongly correlated with their lower social belonging expectations with learners in STEM majors and with the lower gender differences in interest in STEM majors. Social belonging expectation is defined as one’s awareness of socially fitting in with others (Tellhed, et al., 2017).

In addition to negative stereotypes about girls’ intellectual capabilities, there are perceptions about STEM workers as “nerdy” or socially awkward Boston & Cimpian, 2018). During middle school, Modi, Schoenberg and Salmond (2012) found that girls begin to lose interest in math and science. Jacobs (2005) contends that girls tend to prefer careers that provide opportunities for them to help others and benefit the world (e.g., teaching, childcare, and animal care). South African women mostly enrolled in three study fields between 2010 and 2016, even though they constituted a large share of public university enrolments. Education, humanities, and social sciences comprised these categories. Among STEM enrolments, only 46.2% of students were female (StatsSA, 2016; DHE&T, 2019). The low interest in mathematics may be a result of older stereotypes about girls' ability to perform poorly in maths, or low self-confidence, or it could be indicative of girls’ overall well-roundedness, resulting in many turning to their verbal abilities when planning their careers (Modi, Schoenberg, & Salmond, 2012). According to Dasgupta and Stout (2014), girls shift away from STEM areas during the childhood and adolescent stages due to parental expectations for daughters, peer pressure, masculine stereotypes about STEM, and a lack of alignment with personal objectives.

**Theoretical and Conceptual Background**

The theoretical lens used in this study was the social cognitive career theory (SCCT), by Lent, Brown and Hackett (2000). The SCCT explains three interrelated elements of career development, namely how educational and career choices are formulated, how basic academic and career interests develop and how academic and career success is gained. The theory is based on three constructs. These are, 1) self-efficacy beliefs which refers to an individual’s personal belief about her/his abilities to perform a specific action,
outcome expectations which related to the belief about the results or outcomes of certain behaviours and 3) goals which is one’s intention to engage in a particular activity (Lent, Brown & Hackett, 1994). The SCCT has constantly been used as the key theoretical framework in investigating factors that have contributed to the underrepresentation of women in STEM fields (Fouad & Santana, 2017). According to SCCT, high self-efficacy beliefs positively influence one’s outcome expectations and interest in a particular field or career (Clarke-Midura, Sun, Pantic, Poole, & Allan, 2019). In line with the SCCT, parents, friends, and teachers, play a role in deciding the choice of a career. This is confirmed by previous studies which found that students’ belief in their own ability in STEM subjects increased when parents, teachers and friends stressed the value and importance of STEM skills (Buday, Stake, & Peterson, 2012; Rabenberg, 2013; Milam, 2012). Furthermore, parents, friends and teachers help in the development of children’s self-efficacy.

Research and Methodology

Research design
A qualitative design and case study approach within an interpretive paradigm was employed in this study. Participants' feelings, opinions, and experiences are described in detail in qualitative research; and the meanings behind their actions are explained (Denzin, 1989; Saunders & Lewis, 2011. When using a case study method, a small geographical area or a few individuals are selected as study subjects (Yin, 1994). The case study method enabled the researcher to closely examine the data within a specific context. As Antwi and Hamza (2015:219) point out, the interpretive paradigm views the world as constructed, interpreted, and experienced by people in their interactions with others. According to the interpretive paradigm, the world is not fixed; instead, people make meaning from it as they interact with it. As a result of cultural, historical, and political influences, meaning is shaped differently by individuals. Understanding social members' experiences and perceptions of their situations based on their unique backgrounds and contexts is therefore important.

Participants
The research site was conveniently sampled because of the Community Engagement Project, Tateni: Breaking the Cycle of Poverty (T-BCOP) and in collaboration with the Department of Public Works and Infrastructure (DPWI). The research site has the only STEM subject specialised school in the district. The invitation to participate in the study was open to all girl learners in the school. Self-selection sampling was used in the selection of the participants. Therefore, only those girl learners who showed an interest congregated at the agreed venue and time participated in the study. In the end, a sample of ten girl learners in the last three years (Grade, 10, 11, 12) of high school participated in the study. From Grade 10, there were three learners; Grade 11 there were five and Grade 12 two learners. The ages of the girl learners were between 15 and 18 years. Most of the girl learners were studying civil technical subject (60%). The rest were split equally between mechanical technical (20%) and electrical technical (20%) subjects respectively. Permission to conduct this study was obtained from the University of South Africa and the study was conducted according to the prescribed ethical standards. All identifying information such as first names and surnames were treated confidentially and removed before the data analysis. More importantly, the participants did not receive any benefits in-kind or financial. A questions-and-answers session was held, during which the researchers explained what research ethics were, the purpose of the study, the participants' rights, and anonymity. All participants gave individual written informed consent to participate in the study.

Figure 1: No. of participants per subject
Data collection

A focus group was selected as the data collection technique. Moreover, a focus group was suitable for this study because it purposefully zoomed in the perceptions, feelings, and thoughts of participants (Krueger, 2014). The focus group discussion lasted approximately two hours. During the focus group discussion, the learners were asked three questions, a) why did you choose to attend high school at a STEM-focused school instead of a comprehensive school? b) what support have you received around choosing to attend high school at a STEM-focused school? and c) what support have you received around which career to choose?

Data analysis

The focus group discussion was audio-recorded and later transcribed verbatim for thematic analysis to be conducted. The analysis started with the first researcher reading and re-reading the data corpus and making notes of her early impressions. The segments of data that were relevant to the research question were coded. The researchers used open coding by developing and modifying the codes as they worked through the coding process. Similar codes were then grouped together to form themes. The themes were then reviewed and modified to develop preliminary themes. The data related to each theme was re-read to check that it supported the theme. Lastly, the themes were then defined.

Findings and Discussions

Findings

There were four main themes that emerged from the data analysis. These include primary school experience, perceptions of difficulty of STEM subjects, employment and entrepreneurial opportunities and breaking stereotypes and being a role-model.

Primary school experience

Participants had positive views of technical subjects they were doing. These positive views were acquired from primary school as indicated by the participants.

“My parents told me to come here because in primary school I was coming home with the things I made in the technology class and they said they were good (the things I made)” (mechanical technical learner).

“I liked technology and drawing at primary, so I decided to come study here” (civil technical learner).

Positive attitudes towards STEM subjects

Participants indicated that they chose STEM subjects based on the perceived level of complexity or difficulty of STEM subjects. All the girl learners mentioned that their subject fields (civil, mechanical and electric) were easy to understand.

“It’s an easy subject because it is practical, and we use our hands” (civil technical learner).

“It’s easy to understand what the teacher is teaching us” (electrical technical learner).

Employment and entrepreneurial opportunities

Some participants referred to employment and entrepreneurial opportunities that would be available to them as a result of studying STEM subjects at a technical high school.
“You can start your own business for example, can help people in the community to build cupboards” (civil technical learner).

“You can also be your own boss, by having a garage and work as a mechanic and fix the cars in the community” (mechanical technical learner).

Breaking stereotypes and being a role-model

It was interesting to note that the girl learners in this study expressed that they chose to study STEM subjects and wished to enter STEM-related careers fields to break existing stereotypes about girls and women in STEM-related fields. It was also apparent during the focus group discussion that the selection of STEM subjects was not only for being a role model to other girl children, but to prove that they can participate in the competitive world more so in the careers that were unfairly reserved for males. Participants boldly mentioned that,

“I want to prove boys wrong because they undermine us [referring to girls] and say we can’t do the things (technical subjects) like they can” (mechanical technical learner).

“There are a few girls who are civil engineers because they undermine going tech subjects and that’s why there are a lot of boys doing tech subjects. Most girls want to be doctors etc. not understanding that there is a need for people who need to build roads, buildings etc. Most girls also think that tech subjects are difficult, but they are not” (civil technical learner).

Discussion

In this study, the participants’ confidence and interest in STEM developed in primary school. This finding underscores the importance of the primary school phase in creating a firm foundation for promoting and encouraging the girls towards STEM subjects and related careers. This confirms Maltese and Tai’s (2010) findings. The Department of Basic Education (DBE) has already taken strides towards including STEM subjects at the primary school phase with the inclusion of coding and robotics in the curriculum (DBE, 2019). However, this initiative needs to go further and include a focus in science, engineering and mathematics which are important STEM fields especially as the National Development Plan (NDP) has highlighted the importance of science, engineering, technology as the key drivers of development in the country (NDP, 2011). Additionally, studies show the importance of engaging learners in science at the primary school level as this could serve as a springboard for students’ future interest in science, as the average age of initial interest in STEM is 8.2 years (James, Beni, & Stears, 2019; Peterson, Gaskill, and Cordova 2018; Russell, Hancock & McCullough, 2007).

Contrary to research that indicates girls are not as drawn to STEM subjects as their male counterparts (Choudhury 2014; Modi, Schoenberg, & Salmond, 2012; Mostafa, (2019); The AAS (2020), this study found the contrary. The girl learners had positive attitudes and confidence towards STEM subjects and STEM-related careers as well as positive self-efficacy in STEM subjects. Considering the dominant narrative about girls’ low levels of confidence in the STEM fields, this was an encouraging finding. These findings are similar to the study by Siddiqa and Braga (2019) on girls in rural Bangladesh that also found that the girl participants in their study were confident and interested in STEM subjects. In the present study, the girls also showed a keen interest in STEM subjects and STEM-related fields. The participants in the present study reported that they had STEM aspirations as indicated in their STEM-related career choices they articulated, even when they chose to become entrepreneurs. This supports the assertion by Maltese and Tai (2011) that STEM aspirations lead to STEM-related career choices. Similarly, Siddiqa and Braga (2019) found that the girls in their study had high aspirations for their future and looked forward to getting good jobs. Studies have shown that rural youth had a slight but significantly lower level of educational aspirations compared to urban youth, which they credited to rural students having, on average, lower socio-economic status than non-rural students. Rural learners and black minority ethnicity learners in deprived areas have been found to aspire less frequently to professional jobs or STEM-related fields and more likely to study social sciences, law and business and administrative subjects, which are not considered ‘difficult’ (Haller & Virkler, 1993; Mcmaster, 2017). This, however, was not the case in the present study.

It was evident in this study that participants were aware of the stereotypes associated with girls’ abilities in STEM subjects. Therefore, they indicated their plans to persist towards STEM careers. Since the girls attend the only technical high school in the district, it was not surprising that the participants indicated they wanted to also be role-models for other girls in their community so that other girls can also follow in their footsteps. The participants’ need to be role-models suggests that the participants have limited access to role models themselves and so seek to close this gap for other girls in their community. This is important because role model exposure has a positive impact on academic sense of belonging among STEM students and a positive impact on academic self-efficacy among these student (Shin, Levy, & London, 2016). Furthermore, students’ exposure to role models who are not European American males and role models who obtained success through hard work and effort (rather than natural ability) can dispel the two stereotypes about STEM that are, firstly that STEM is for European males and lastly that, one must be naturally gifted to succeed in STEM (Shin, et al., 2016). By being role models for other girls, the participants in the present study will be able to make other girls feel “suited” and a sense of belonging in STEM.
Conclusions

The goal of this study was to look at the motivating elements that lead female students to pursue technical fields of study and employment. This study was crucial and pertinent in addressing the STEM education research focus that prioritized science and mathematics over technology and engineering. So, a unique sample of girls studying technical topics at a technical high school in a remote location was used in the study.

This study identified four enabling factors. These included having attended elementary school, having parents who were supportive, becoming prosperous through job and entrepreneurial opportunities, overcoming preconceptions, and setting an example. The results of this study supported the need for females to be exposed to technical courses in elementary school in order to increase their confidence in choosing STEM majors in high school and subsequently associated occupations. Technical fields and related occupations are relevant to this study. Despite attending a rurally underserved technical high school, the survey also revealed that the girls had high hopes for their futures in STEM-related occupations as well as personal ambitions. It was discovered that the girls’ social background and lack of role models had a beneficial impact on their motivation to serve as role models for other girls in their neighborhood. Therefore, making an effort to do away with the racial and socioeconomic divide that has long been associated with the perception of who should pursue STEM-related occupations. The participants in this study were unique in that they cared about their community’s improvement through the entrepreneurial prospects they anticipated since they studied technical courses in addition to having personal aspirations for themselves. These results are helpful in two ways. First, parents, particularly those in rural areas, should be aware of the impact they have on their daughters’ choices of STEM subjects in school because it has an impact on their careers. If parents are knowledgeable about STEM subjects and STEM careers, they can pass that knowledge on to their children. The study can also help the Department of Education, corporations, non-governmental organizations (NGOs), and employers because it offers these parties insights to help them plan, design, and implement effective strategies to encourage girls from economically and socially disadvantaged backgrounds to consider STEM subjects and STEM careers, particularly technical subjects. This study has limitations, much like any other study. The research’s conclusions are based on data from a small exploratory study sample of female students at a technical high school in a remote area. This restricts the generalizations that may be drawn from the results.

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