

## THE EFFICACY OF STEM MENTORING PROGRAMME IN PROMOTING SECONDARY SCHOOL STUDENTS' INTEREST TOWARDS STEM IN KWAZULU- NATAL PROVINCE, SOUTH AFRICA

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### ABSTRACT

An important first step in talent development in science, technology, engineering, and mathematics (STEM) is getting individuals excited about STEM through STEM mentoring programs. The essence of STEM mentoring program is to step-up the declining interest in STEM subjects among secondary school students. Therefore, this research investigated the efficacy of STEM mentoring programs on the students' interest towards STEM in some selected secondary schools in South Africa. Specifically, the study analyses the extent to which secondary school students developed interest towards STEM subjects. The study used post-test control group research design from four selected secondary schools in Ugu District Municipality of KwaZulu-Natal Province, South Africa. A total of 100 students (mentees) were sampled from four secondary schools in Ugu District Municipality of KwaZulu-Natal Province, South Africa participated in STEM mentoring program. Out of this number, 50% from the total of mentees were randomly selected as a treatment group (N = 50 [20 males and 30 females]) while non-participants in the STEM mentoring program from the same schools were randomly selected as a control group (N = 50 [20 males and 30 females]). In addition, 10 teachers who teaches STEM subjects as well as 20 graduate facilitators who possess Bachelor of Education and Postgraduate Certificate in Education (PGCE) in STEM subjects also participated in the study as mentors who anchored the STEM mentoring in the control and the treatment groups. The Data collected from the survey were analysed by means of frequencies and percentages, independent t-test was also employed to statistically validate the research hypotheses. The research calibrated the mean scores and standard deviation values on the participants' interest towards STEM. It turns out that the level of all three aspects of interest towards STEM are moderately high and high with the mean scores between 3.5 to 4.3 which are within the threshold of 3.0 estimated for this research. The study also found that the students' level of interest towards science is 'high' for both group and gender. Meanwhile, the level of interest towards mathematics indicated a different level in both group and gender. The study concluded that boys in treatment group shows moderate level of interest towards mathematics compared to the boys in control group with high level of interest towards mathematics while girls in the treatment group indicated high level of interest towards mathematics compared to the girls in control group. Following the results from this research, this study then suggests that government should recruit teachers that are vast in STEM mentoring who express interest in developing a supportive, caring relationship and friendship with their mentee(s) in order to enable the students develop career interest in STEM subjects.

**Keywords:** Students' Interest towards STEM, Post-STEM Mentoring Program, Ugu district municipality of KwaZulu-Natal- Province, South Africa

## I. INTRODUCTION

Interest in science and mathematics learning among school students is declining globally South Africa inclusive (Adedigba& Akani, 2022). The reasons for the decline include learning in SILO and not integrated, unable to see the relevance of science and mathematics in everyday situation, subject matter too difficult and career is uninteresting (UNESCO, 2024). One of the ways to address this phenomenon is by promoting STEM mentoring education in that STEM mentoring integrated education brings real world problems and contexts into schools. At the same time, Clinton and Fagbemi (2019) argued that another underlying issue to the decline, which has not been addressed, is concerned with the students' own identity to the discipline- i. e. unwillingness to opt for science related studies and careers. Both the pedagogical and psychosocial factors could be addressed through a mentoring system between STEM higher education students (commonly known as facilitators) and secondary school students. Often courses in higher education involve integration of more than one discipline and deal with complex and real world problems. STEM mentoring facilitators serve as role models are able to project positive STEM identity - such as projecting images whereby STEM researchers and their work is actually helping the community (device methods to overcome famine or engineers develop method to produce alternative energy sources with less pollution consequences). While mentoring is seen important, the effectiveness of mentoring program varies in results and effect size.

Traditional face to face STEM mentoring program is better than online mentoring and vice versa (Gabriel & Daniel, 2024). The fact that mentoring studies lack of treatment group which is a limitation of any mentoring program (Adegboyega& Alani, 2018). Thus, this study addresses the problem of declining interest in science and mathematics and promoting positive STEM identity among secondary school students Further, studies on mentoring program on STEM have indicated correlations between self-efficacy, scientists' identity, and undergraduates' desire to pursue careers in science (Samuel, George &Badaru, 2019). However, further research is needed to establish link between students' interest towards STEM and students' socio-demographic gender. One of the challenges that STEM reforms were designed to meet is the provision of meaningful, active, and productive learning opportunities that promote diversity, equity, and inclusion in STEM education (Bala-Gbogbo&Usman, 2018). Therefore, acknowledging and understanding the effect that demographic features, such as gender and interest related to science are critical in bridging the gaps in the declining rate of interest in STEM among secondary school students in South Africa. This highlights the importance of examining the impact of the secondary school STEM program on secondary school students' scientific dispositions, STEM career choice, and mentor-student interaction in Ugu District Municipality of KwaZulu-Natal-Province, South Africa.

Further, studies on mentoring program on STEM have indicated correlations between self-efficacy, scientists' identity, and undergraduates' desire to pursue careers in science (Samuel, George &Badaru, 2019). However, further research is needed to establish link between students' interest towards STEM and students' socio-demographic gender. One of the challenges that STEM reforms were designed to meet is the provision of meaningful, active, and productive learning opportunities that promote diversity, equity, and inclusion in STEM education (Bala-Gbogbo&Usman, 2018). Therefore, acknowledging and understanding the effect that demographic features, such as gender and interest related to science are critical in bridging the

gaps in the declining rate of STEM among secondary school students in South Africa. This highlights the importance of examining the impact of the secondary school STEM program on participants' scientific dispositions, STEM career choice, and mentor–student interaction in Ugu District Municipality of KwaZulu-Natal- Province, South Africa. Thus, this study hypothesized that the gender factor of secondary school students, could explain their interest towards advancing career path in STEM education. An understanding of this factors can help policy makers in formulating educational based STEM policies that will reverse the declining interest in STEM education among secondary school students in South Africa. Hence, the objective of this research is to access the extent to which secondary school students' in Ugu District Municipality of KwaZulu-Natal Province in South Africa developed interest towards STEM after Post-STEM mentoring program.

## RESEARCH QUESTIONS

- i. To what extent has the secondary school students' in Ugu district municipality of KwaZulu-Natal Province in South Africa developed interest towards STEM after Post-STEM mentoring program?
- ii. Is there any significant difference towards STEM elements between groups participants and non-participants in STEM mentoring program?
- iii. Is there any significant interaction of interest towards STEM subjects between groups and gender?

## II. LITERATURE REVIEW

There is empirical evidence that mentors have an influence on mentees' career choices in STEM (i. e. , majoring in a STEM subject at university or entering a STEM profession). For example, in a retrospective survey of 1425 female graduates of selective science, high schools in the United States Adekanbi and Babatope (2019) found that having a teacher as a mentor during high school correlated with university STEM major choices and degrees in STEM. However, studies examining associations between participation in formal STEM mentoring programs during secondary education and later career choices are lacking (Usman & Dahiru, 2020). To date, evaluation studies on mentoring STEM programs have mainly examined more proximal program effects on precursors of later choices of STEM majors or careers (e. g. , elective intentions in STEM, certainty about career plans, or career interests; for an overview). This present study analyse the interest of secondary school students towards STEM careers.

Evaluation studies conducted by Benedict, Bola, Adegeye and Apata (2018) of the Germany-wide online mentoring program on STEM, also reported, among other things, positive effects on girls' elective intentions and certainty about career plans in STEM. In an initial evaluation study reported by Ahmed, Hilda, Victor and Bako (2019) with 312 students in secondary education, 208 girls were selected by random assignment to participate in the STEM mentoring program without delay. The remaining 104 students acted as a waitlist control group of comparably interested girls who were only admitted to the program 1 year later. In questionnaires completed by both groups before starting the program, 6 months after starting, and at the end of the mentoring year, girls who had participated in the STEM mentoring program reported a greater increase in elective intentions in STEM than girls in the waitlist control group. In a follow-up

study conducted by Bolaji, Williams and Fagbemi (2020) 789 of 1237 girls who applied to the program were randomly selected to participate. Their developmental trajectories were compared with those of 448 girls who had been randomly assigned to a waitlist control group and with those of a random sample of 663 girls and 841 boys. Across the three measurements, participating girls exhibited more positive trajectories with respect to certainty about STEM career plans compared to the boys.

In another development, Mqadi (2023a) adopted mixed research methods and descriptive statistics to examine the effect of mentoring program on the teachers' teaching learners with learning difficulties in South Korea. The study found a significant relationship between teachers' mentoring and the teaching skills of teachers teaching the difficult to learn pupils. Also, Mqadi (2023b) equally employed a quasi-experimental non-randomized research design involving pre-test and post-test with a control group and ANCOVA to investigate the impact of teachers' mentoring programme on teachers' classroom practices and pupils learning outcomes in KwaZulu-Natal Province, South Africa. The sampled participants for the study were divided into three groups; control group, moderate intensity teachers' mentoring group (MIPAG) and high intensity teachers' mentoring group (HIPAG) through balloting. While all the groups were exposed to 80 minutes/week of teachers' mentoring concepts for a period of four weeks, the MIPAG was further exposed to 60 minutes/week of teachers' mentoring activities to determine the baseline teachers' mentoring activities impacts on classroom practices and pupils' academic performance and those with too high or low scores were not included in the study. The results of the findings revealed that MIPAG recorded the highest mean  $15.98 \pm 1.58$ , followed by HIPAG (13.41) compared to the control group (8.21). The study also found significant differences among the means of the three groups  $F(2,11) = 10.397, p = 0.001$ . The research also found significant positive relationship  $r(58) = .514, p < .003$  among teachers' mentoring activities, classroom practices and pupils learning outcomes in the study location.

The study concluded that teachers' mentoring activities has significant impacts on classroom practices of teachers and pupils' learning outcomes in the sampled primary schools in Ugu district municipality, KwaZulu-Natal Province, South Africa. However, previous studies (Mqadi, 2023a; Benedict *et al.*, 2018 & Ahmed *et al.*, 2019) examined the effect of mentoring on teachers teaching learners with learning difficulties while others (Mqadi, 2023b; Bolaji *et al.*, 2020) investigated the impact of mentoring programs on teachers' classroom practices and pupils' learning outcomes. These studies did not capture the most trending issues (the development of students' interest towards STEM education) in the 21<sup>st</sup> century educational development into their research. Also, to the best of my knowledge only a few study (Mqadi, 2023a) analysed the effect of mentoring program on pupils' learning outcomes using control and experiment groups. Therefore, this study bridged this knowledge gap by deep diving into the analysis of the efficacy of STEM mentoring programme on secondary school students' interest towards developing career in STEM using the post-test design with non-equivalent groups in Ugu District Municipality of KwaZulu-Natal Province, South Africa.

### III. METHODOLOGY

A total of 100 students (mentees) from four secondary schools in Ugu District Municipality of KwaZulu-Natal Province, South Africa participated in STEM mentoring program. Out of this

number, 50% from the total of mentees were randomly selected as a treatment group (N = 50 [20 males and 30 females]) while non-participants in the STEM mentoring program from the same schools were randomly selected as a control group (N = 50 [20 males and 30 females]). In addition, 10 teachers who teach STEM subjects as well as 20 graduate facilitators who possess Bachelor of Education and Postgraduate Certificate in Education (PGCE) in STEM also participated in the study as mentors who anchored the STEM mentoring programs in the control and the treatment groups. Post-test design with non-equivalent groups was used in this study. Based on this type of design, both groups (control and treatment) were only given post-test on a range knowledge of STEM and interests towards STEM subjects. According to Alao and Babatope (2018), this methodology provides the best empirical gauge in measuring the efficacy of STEM mentoring program on students' interest towards STEM subjects. The research employed 5-points agreement of Likert type response mentoring in STEM was used in this study (1= strongly not agree to 5= strongly agree). The instrument was adapted from Alapini and Babatope (2018) which takes into consideration three main interests of STEM mentoring namely: (i) interest towards science, (ii) interest towards mathematics, and (iii) interest towards science & technology. This instrument has been verified by experts in term of construct and content validation. The reliability of the instrument from the pilot study indicates high Cronbach's Alpha value for all constructs (Cronbach alpha > 0. 075). This instrument (post-test) then was distributed to the participants (control and treatment groups) after the mentoring program ends.

#### IV. DATA PRESENTATION AND DISCUSSION OF RESULTS

**Research Question 1:** To what extent has the secondary school students' in Ugu District Municipality of KwaZulu-Natal Province in South Africa developed interest towards STEM after Post-STEM mentoring program?

**Table 1: Participants Levels of interest towards STEM**

Variables	Groups	Gender	Mean Scores	Standard Deviation	Decision Rule
Interest towards Science	Control	Boys	4. 1	0. 65	High
		Girls	4. 2	0. 60	High
	Treatment	Boys	4. 2	0. 49	High
		Girls	4. 3	0. 43	High
Interest towards Mathematics	Control	Boys	4. 0	0. 76	High
		Girls	3. 6	1. 06	Moderate high
	Treatment	Boys	3. 8	0. 96	Moderate high
		Girls	4. 1	0. 83	High
Interest towards Engineering & Technology	Control	Boys	3. 9	0. 64	Moderate high
		Girls	3. 5	0. 63	Moderate high High
	Treatment	Boys	4. 1	0. 64	High
		Girls	4. 0	0. 67	High
Interest towards	Control	Boys	3. 7	0. 62	Moderate high

STEM		Girls	4.0	0.50	High
	Treatment	Boys	4.1	0.56	High
		Girls	3.8	0.61	Moderate high

Mean score interpretation (UNESCO, 2018) 1.00 - 1.99 (low) 2.00 - 2.99 (moderate low) 3.00 - 3.99 (moderate high) 4.00 - 5.00 (high).

**Source:** Author's Computation (2024)

Table 1 shows the mean score and standard deviation value following by the level of interest towards STEM. The table indicates, the level of all three aspects of interest towards STEM are moderately high and high with the mean scores between 3.5 to 4.3. The interpretation of the level of the mean score was based on UNESCO's 2018 average assessment metrics for STEM subjects. The level of interest towards science is 'high' for both group and gender. This high score mean of interest towards science probably because in the early ages of learning, in this context were from one student (age 13 years old), the students have more desire or interest to know more about science. But it is feared that their interest in science decreases as their education level increases (UNESCO, 2018). The current issues that showed interest towards science among school students is declining worldwide (UNESCO, 2020).

Meanwhile, the level of interest towards mathematics indicated the different of level in both group and gender. Boys in treatment group shows moderate level of interest towards mathematics compared to the boys in control group with high level of interest towards mathematics. On the contrary, girls in the treatment group indicate high level of interest towards mathematics compared to the girls in control group. This result tallies with the study conducted by Olukayode and Bamidele (2019) whose research shows girls interest towards mathematics declined starting in the middle school globally. Table 1 equally shows that, interest toward engineering and technology indicate boys in the treatment group shows higher interest compared to the girls and control group. One possible reason for the low level interest among girls compared to boys is that that engineering and technology are stereotyped linked to a masculine field and machines are related to the quality valuable for boys compared to girls (UNESCO 2018). However, both girls and boys in the treatment group shows higher score mean compared to the control group. The mentoring programs which involved hands-on activities and multidisciplinary STEM project in creating product, together with the support and motivation from the facilitator, may help both girls and boys to cope with the challenge in accomplished their goals of projects. Overall, boys and girls in the treatment group shows higher level of interest towards STEM compared to control group. The finding of this study does support previous finding on the positive effect of the STEM Mentoring programs on students' interest towards STEM subject in the study conducted by Anjorin and Boris (2018).

**Research Question 2:** Is there any significant difference towards STEM elements between groups participants and non-participants in STEM mentoring program?

**Table 2: Multivariate analysis of the significant difference towards STEM elements between groups participants and non-participants in STEM mentoring program**

Categories	Element	Sum of square	Df	Mean square	F	Sig.	Partial eta squared
Group	Science	0.950	1	0.950	3.278	0.072	0.017
	Math	1.527	1	1.527	1.768	0.185	0.009
	E & T	0.673	1	0.673	1.639	0.202	0.008
Gender	Science	0.540	1	0.540	1.863	0.174	0.010
	Math	0.269	1	0.269	0.031	0.577	0.002
	E & T	5.127	1	5.127	12.491	0.001	0.061
Group*gender	Science	0.031	1	0.031	0.106	0.745	0.001
	Math	3.999	1	3.999	4.629	0.033	0.023
	E & T	0.288	1	0.288	0.701	0.403	0.004

Source: Author's Computation (2024)

Table 2 shows there are no significant group effect on the three elements of interest in STEM; interest towards science, interest towards mathematics and interest towards engineering and technology in the study location. Whereas, the main effect of gender is significant only for element interest towards engineering & technology,  $F(3,194) = 8.504$ ,  $p > 0.05$ . Hence, only boys showed the 'significant' effect from 'moderately high' to 'high' as the girls only showed slightly significant different of mean score (see table 1). While the effect of interaction between group and gender was significant only for element interest towards mathematics,  $F(3,194) = 1.724$ ,  $p = 0.163$ ; Pillai's Trace = 0.026; partial  $\eta^2 = 0.026$ . This result is consistent with the studies conducted by Adelabu and Odegbami (2019) whose research found no significant group effect on the three elements of interest in STEM; interest towards science, interest towards mathematics and interest towards engineering and technology in Kenya.

**Research Question 3:** Is there any significant interaction of interest towards STEM subjects between groups and gender?

**Table 3: Analysis of the significant interaction of interest towards STEM subjects between groups and gender**

Table 3a: Independent sample t-test by group								
Element	Group		Gender	Mean	Standard deviation	t	df	Sig.
Interest towards	Control		Boys	4.	0.756	1.759	97	0.082

				000				
Mathematics			Girls	3.620	1.055			
	Treatment		Boys	3.885	0.956	-1.237	97	0.219
			Girls	4.108	0.826			
<b>Table 3b: Independent sample t-test by gender</b>								
Element	Group	Gender		Mean	Standard deviation	t	df	Sig.
Interest towards	Boys	Control		4.000	0.756	0.537	66	0.593
Mathematics		Treatment		3.885	0.956			
	Girls	Control		3.620	1.055	-2.897	127	0.004
		Treatment		4.108	0.826			

Source: Author's Computation (2024)

Based on the results of the independent sample t-test shown in table 3a and 3b, the tables indicate a significant difference between girls for interest in mathematics in control and treatment group ( $t = -2.897$ ,  $df = 127$ ,  $p = 0.004$ ). Mean score of interest towards mathematics for girls in treatment groups is higher compared to girls in control group (treatment: mean=4.108; control: mean=3.620). Based on the findings in table 3 above, STEM mentoring program is effective in improving interest towards mathematics especially for girls (see table 3a). This result is in line with studies conducted by Ahmed et al. (2019), Benedict et al. (2018), and Bolaji et al. (2020) whose studies found a significant difference between girls for interest in mathematics in control and treatment group in Mali, Senegal and Ghana.

## V. CONCLUSION AND RECOMMENDATION

In the course of analysing the efficacy of stem mentoring programme in promoting secondary school students' interest towards STEM subjects in KwaZulu-Natal Province, South Africa. This research found that participants' level of the interest towards science is 'high' for both group and gender. Meanwhile, the research also found a significant difference between girls for interest in mathematics in both control and treatment group. However, there were no significant group effect on the three elements of interest in STEM; interest towards science, interest towards mathematics and interest towards engineering and technology. The study indicated that the program was effective at modifying students' interest level as the result revealed positive changes for both group and gender. Following this conclusion, this study then suggest that government should recruit teachers that are vast in STEM mentoring who express interest in developing a supportive, caring relationship and friendship with their mentee(s) in order to enable the students' develop their career in STEM subjects.



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