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Evaluating Teachers' Influence on Students' Attitudes towards STEM Subjects from Selected Secondary Schools in Bayelsa State

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ABSTRACT
This article attempts to assess teachers' influence on students' attitude towards science, engineering, mathematics (STEM) subjects in secondary schools in Bayelsa State, Nigeria. We specifically sought to find answers to whether certain characteristics of teachers—teachers' pedagogical content knowledge (PCK), teachers' mastery of content knowledge, teacher enthusiasm, and teacher temperament contribute to secondary school students' attitudes towards the choice of STEM subjects and subsequent future careers. Employing a survey design for the study, we used researcher designed questionnaire on a 4-point Likert-style scale to collect data. Data were analysed using the item means. Results revealed that the identified variables influenced students' attitudes toward STEM subjects. This study builds on existing literature by examining students' attitudes towards science, technology, engineering and mathematics in senior secondary schools in a developing world context. Attempt is made here to create the much-needed awareness in order to foster in students, a positive attitude towards STEM subjects, especially when they are making choices regarding their future careers at the university level.

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INTRODUCTION

The global COVID 19 pandemic has once again, brought to fore, the urgent need for people skilled in science, technology, engineering and mathematics (STEM) related disciplines. It is pertinent to note that for a country like Nigeria which is already an underrepresented country in terms of critical technical skills (CTS) and the production of scientific knowledge within the global science and technology space; ignoring Lockton's (2013) assertion that: 'engineering, technological and scientific education is important now and will even be more in the years to come' will be suicidal to the country. Truly speaking, STEM education – is vital to our future – the future of our country, the future of our region and the future of our children (Science Pioneers, 2015). A consensus exists amongst researchers that a country's economy and competitive strength suffers if there is a shortage of people with STEM skills and competencies (Bennett, Braund and Sharpe, 2014).

However, STEM related professions are finding it difficult to produce enough graduates to meet workforce needs in these fields (Hall, Dickerson, Batts, Kauffmann and Bosse, 2011). The case for Nigeria and other African countries, if anything, does not seem attractive. For instance, a World Bank assessment of the African continent's share of doctors, engineers, scientists and researchers, expressed deep concerns

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over the CTS shortages in terms of both the numbers and quality in Sub-Saharan African countries, maintaining it has reached unimaginable proportions (Kigotho, 2014).

Identifying the problem and knowledge gaps

Attitude towards science subjects has been viewed as one crucial pre-dispositional factor in individuals' choice of science-related careers and teachers play a significant role in modelling students' attitudes (Fulmer, Ma and Liang, 2019; McDonald, 2016; Osborne et al., 2003). However, the problem is that, while these issues have been extensively discussed in the literature, the influence teachers' characteristics exert on students' interest towards STEM subjects, especially for developing countries like Nigeria have not received adequate attention. Hence, this study attempts to fill that knowledge gap by exploring the impact teachers' characteristics has on students' attitudes towards science, technology, engineering and mathematics.

Aim and research questions

The main aim of the study was explore the role of teachers in influencing students' attitudes towards STEM subjects in senior secondary schools in Bayelsa State, Nigeria by: investigating the reason why some suitably qualified students do not continue their education in science-oriented studies at the higher education level despite their previous interest in science-related topics in secondary education; and to examine the impact some teachers' characteristics that may influence students' attitudes towards STEM subjects in the study context.

The specific objectives were: 1) to determine the influence of teachers' pedagogical content knowledge (PCK) on students' attitudes towards STEM courses; 2) to ascertain the influence of teachers' mastery of content knowledge on students' attitudes towards STEM courses; 3) to find out if the enthusiasm of a teacher influences his/her students' attitude towards STEM subjects; and 4) to assess the influence of teachers' temperament on students' attitude towards STEM subjects.

Accordingly, the research questions that guided the study were: 1) Do teachers' PCK influence students' attitude towards STEM subjects? 2) How does teachers' mastery of subject content knowledge influence students' attitudes towards STEM subjects? 3) Do teachers' enthusiasm influence students' attitude towards STEM subjects? 4) How does teachers' temperament influence students' attitude towards STEM subjects?

The rest of the paper is structured as follows: the next chapter explored related literature on attitudes. Section 3 provides a description of the materials and methods adopted for the study. Next, we presented the results, analysis and discussions of the findings in Section 4. Conclusions, limitations and implications for future study were provided in Section 5.

LITERATURE REVIEW

Attitude has become an important area of educational research because numerous studies have linked students' attitudes towards the STEM domains to students' achievements in mathematics and other science subjects (see for example: Fulmer et al., 2019; Gokhale and Machina, 2014; Kazár, 2014; Gokhale, Rabe-Hemp, Woeste and Machina, 2015; Osborne et al., 2003). Students' attitude towards science is also seen as a measure of learning and teaching of STEM related subjects (Astalini, Kurniawan, Kurniawan and Anggraini, 2019) and thus recognised as valuable outcome of science education (Fulmer et al., 2019).

Potvin and Hasni (2014) undertook a systemic review of over 200 articles students' attitudes towards science and technology with many of them referring to "the construct of attitude as including components such as—cognitive,

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affective, behavioural, and the idea of positive or negative (like or dislike) inclinations towards an object. Similarly, some of the "articles suggested that attitude was a complex construct that contains many sub-constructs, among which 'interest, enjoyment, motivation and perceived difficulty, yet others incorporated self-efficacy, identity utility, career aspirations, beliefs and feelings" (p. 95).

Attitude is the degree of evaluative affect towards a target behaviour (Gokhale and Machina, 2014; Gokhale et al., 2015) and the behaviour itself is determined by the beliefs and attitudes of that individual (Gokhale et al., 2015). However, Osborne et al. (2003) stated that affective attitudes towards science in particular: "*are the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves*" (p. 1054). Gokhale and Machina (2014) added that an individual can focus those set of beliefs towards an outcome of performing a specific behaviour, he/she then forms either a favourable or an unfavourable attitude about performing that behaviour (for example, selecting a STEM major).

On the other hand, Ing and Nylund-Gibson (2013) argued that attitudes are malleable and can be influenced by many factors. Some of those factors that influence students' attitudes towards STEM subjects in secondary schools are: expectancies, motivations, student characteristics, previous achievements, related experiences and interests (Kazár, 2014), gender, environmental factors, classroom/teacher factors, teachers and family support (Ing and Nylund-Gibson, 2013). Other school factors that may also influence uptake in STEM subjects include: the type of school and the student intake (selective or all ability, single-sex or co-educational), the ethos of the school, the school management, the curriculum on offer, teacher effects, and career advice offered to students (Bennett et al. 2014), a perceived lack of relevancy to students' everyday lives, and ineffective transmissive teaching strategies (McDonald, 2016). Nevertheless, student attitude towards the learning process remains the most impactful factor at school (Suyatno, Mardati, Pambudi and Amurdawati, 2019).

Again, while the range of interpersonal influence was wide, students' STEM choices were often influenced by other persons (Sjaastad, 2012), such as the role of significant others or persons (e.g. parents, professors/teachers, friends, relatives, peers and counsellors) on students' choice to either stay or leave the STEM pipeline have been examined by some researcher (Korpershoek et al., 2012; Sjaastad, 2012). It is claimed that student–teacher relationships were key to forming students' attitude towards formal education Hollingworth and Archer (in Alcott, 2017) and that there was qualitative evidence of the potential for teachers' social interactions widening access for underrepresented groups. Indeed, significant persons, particularly teachers influence students' choice to leave the STEM pipeline (Hall et al., 2011; Korpershoek et al., 2012) as several studies have demonstrated that teachers exert a big influence on students' subject choices in secondary education (Kazár, 2014; Korpershoek et al., 2012). Truly speaking, teachers can influence students' feelings towards a subject, either positively or negatively (Cherian, 2006).

Similarly, a study conducted by Lichtenstein, Tombari, Shepherd and Storm (2014) revealed that, among other factors like - student proclivity, aptitude, and family influence, it was middle and high school instruction that was significantly more influential in those intending to study engineering as their major. Despite the fact teachers play a major role in this regard, most of them are barely aware of it (Suyatno, Mardati, Pambudi and Amurdawati, 2019). This

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means, the role of the teacher as the key facilitator of instruction during this phase of study is paramount.

MATERIALS AND METHODS

The study adopted a descriptive survey design. Data were collected from a representative sample of the population and the findings were generalised to the entire population. Multi-stage sampling technique was employed for drawing the appropriate sample size. A simple random technique was used to select 8 educational zones from the 16 educational zones in Bayelsa State, Nigeria. Simple random sample was again used to draw 56 secondary schools from the 111 secondary schools in the 8 selected zones. Finally, a sample size of 7,161 students were drawn from the population of 23,870 students. All these were sourced from the sampling frame—Bayelsa State Senior Secondary Schools Board, Yenagoa, summary of student population as at June 2015.

The instrument used for data collection was a researcher developed questionnaire titled: Teachers' Characteristics Influencing Students' Attitudes towards STEM subjects (TCISATSS). The instrument was formatted on 4-point Likert-style Scale of strongly agree, agree, disagree, and strongly disagree.

The instrument was validated by experts in measurement and evaluation in the Department of Educational Foundations, Faculty of Education of the Niger Delta University. A reliability coefficient of 0.75 was obtained using Pearson's Product Moment Correlation (PPMC) technique, after two administrations to a sample that was not used for the study. Data were analysed using item mean. A mean score of 2.5 was used for either accepting or rejecting the influence of the variables under study on students' attitude towards STEM subjects.

RESULTS

Table 1: Mean for teachers' pedagogical content knowledge

Variables	Mean	Remark
Teacher's involvement of students while teaching is encouraging	3.20	Agree
Teacher's demonstration ability while teaching is	3.21	Agree
Teacher's questioning techniques while teaching	3.36	Agree
Teacher's ability to explain concepts adequately while teaching	3.26	Agree
Grand mean	**3.26**	**Agree**

Table 1 shows the item mean responses on the influence of teachers' pedagogical knowledge on students' attitude towards STEM subject. All the items eliciting information on the teachers' influence pedagogical knowledge on students' attitudes towards STEM subjects have item mean above 3 points. The grand mean of 3.26 indicates that teacher's pedagogical knowledge influence students' attitude towards STEM subjects.

Table 2: Item mean for teachers' mastery of subject matter

Variables	Mean	Remark
Teacher's ability to explain concepts adequately while teaching	3.35	Agree
Teacher's ability to provide answers to students' questions while teaching	3.27	Agree
Teacher's ability to cover all the topics stipulated in the scheme work while teaching	3.18	Agree
Teacher's ability to provide prompt feedback on tests and assignments	3.13	Agree
Grand mean	**3.23**	**Agree**

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Table 2 indicates that influence teachers' mastery of subject matter has on students' attitude towards STEM subjects. The remark on all the items assessing the influence of teachers' mastery of subjects were agree as they have item means of 3 and above. The grand mean of 3.23 reveals that teachers' mastery of subject matter influence students' attitude towards STEM subjects.

Table 3: Item mean for teachers' enthusiasm

Variables	Mean	Remark
Teacher's energetic nature while teaching	3.11	Agree
Teacher's motivational nature while teaching	3.01	Agree
Teacher's dynamic nature while teaching	3.05	Agree
Teacher's sense of humour while teaching	3.15	Agree
Grand mean	**3.05**	**Agree**

Table 3 reveals the item means responses of teachers' enthusiasm on students' attitudes towards STEM subjects. All the items raised on the influence of teachers' enthusiasm on students' attitude towards STEM subject were found to have influence on students' attitude as they have means above 3 points. The ground mean of 3.05 was an indication that teachers' enthusiasm influences students' attitude towards STEM subjects.

Table 4: Item mean for teachers' temperament

Variables	Mean	Remark
Teacher's reaction to noise makers while teaching	3.20	Agree
Teacher's nature of not being easily angry	3.21	Agree
Teacher's nature of tolerating slow learners while teaching	3.36	Agree
Teacher's nature of politely correcting students while teaching	3.26	Agree
Grand mean	**3.26**	**Agree**

Table 4 shows the item means of the four items eliciting information on the influence of teacher's temperament on the attitude of students towards STEM subjects. The mean rating of all items and also the grand mean was above 3 points, revealing that teachers' temperament influences the attitudes of students towards STEM subjects.

DISCUSSION OF FINDINGS

The need to study students' attitudes towards STEM subjects in Bayelsa State became imperative as several educators have linked achievement in such subjects to students' attitudes (Gokhale and Machina, 2014; Kaizar, 2014; Gokhale et al., 2015; Osborne et al., 2003). Teachers as individuals who are saddled with the responsibility of helping students to learn and behave in an acceptable manner in society will definitely influence their (students') attitudes. It therefore implies that teachers' characteristics such as PCK, mastery of subject matter, enthusiasm and temperament which are the variables under study may have influenced the attitude of students either positively or negatively towards STEM subjects in the secondary schools in Bayelsa State. This by extension will influence students' pursuit of STEM related disciplines in tertiary institutions. Cherian (2016) corroborated the above assertion as he noted that there are many teacher's variables that contribute to improvement in students' attitudes towards STEM subjects.

The results show that teachers' pedagogical content knowledge with a grand mean of 3.26 was agreed to have influenced students' attitude towards STEM subjects in secondary schools in Bayelsa State. This was in consonant with

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McDonald's (2016) study which revealed that teachers' PCK was the foremost factor influencing students' situational science interest. It was also in agreement with the findings from a research by Keller et al. (2017). The view of Keller and colleagues was that teacher PCK contributes to students' learning of mathematics and other science subjects. Similarly, the results also resonate with Geerling's (2012) study. Geerling buttressed his idea by opining that effective institutions builds bridges between students' knowledge and their learning objectives of the course. It is therefore important that STEM subject teachers in Bayelsa State possess the necessary STEM pedagogical content knowledge.

Based on the grand mean of 3.23 as indicated in the results, teachers' mastery of subject matter was also agreed as an influencing factor of students' attitudes towards STEM subjects in Bayelsa State secondary schools. This finding was in line with the view of Ball and McDiarmid (1990); (Cueto, León, Sorto, and Miranda, 2017) who posited that mastery of subject matter and the ability to be critical of the content knowledge can influence students' attitude.

Teacher enthusiasm with a grand mean of 3.05 was also agreed as a factor that influences students' attitudes towards STEM subjects in Bayelsa State. Our findings were in agreement with Kim et al.'s (2014) study. Kim and his colleagues asserted that teacher enthusiasm was an influencing factor on students' interest, development and particularly contributes to students' valuing a course (subject). This implies that teacher enthusiasm will also influence students' attitude towards STEM subjects.

From the results, teachers' temperament with a grand mean of 3.24 was indicative that the respondents agreed to it as a factor influencing students' attitudes towards STEM subjects in the study area. This was in agreement with Chang-Kredl and Colannino (2017) and Nkomo and Fakrogha (2016) who opined that teachers who get angry quite easily can negatively influence students' attitudes towards STEM subjects as this might result in pessimism and negative thoughts and feelings among students.

Based on the discussion of our findings, it can be deduced that all teacher variables: pedagogical content knowledge, mastery of subject matter, enthusiasm, and temperament are influencing students' attitudes towards STEM subjects. Our position has already been established in the extant literature. For instance, Bennett et al. (2014) and Carron (2014) had earlier observed that attitudes were key determinants of students' engagement in STEM subjects and subsequent uptake of STEM career pathways. They therefore concluded that it was not surprising that a very large volume of literature exists on attitudes towards STEM subjects. Interestingly, as of today, enthusiastic teaching is understood as a feature of instruction (Kunter et al., 2008; 2011; Keller et al. 2017). Likewise, teacher temperament is a fundamental component of the instructional process (Tevee, 2017), and some evidence, particularly from developing countries indicate that teachers' SMK impact on student learning (Cueto, León, Sorto, and Miranda, 2017) all of which are critical keys to creating a well–behaved classroom (Nkomo and Fakrogha, 2016).

CONCLUSIONS

In the theory, attitudes towards STEM subjects refer to either a positive or negative feeling a learner has towards science, technology, engineering, and mathematics. In this paper, we found that the teacher variables under investigation contribute to students' developing positive feeling towards STEM subjects. For the fact that teachers have been involved in the process of modelling learners' behaviour for suitable adjustment in the larger society (Ugoani, 2014), the problem of how teachers influence students' learning has been a longstanding question in educational

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research (Kim and Schallert, 2014). But of particular importance was the role of emotional expressiveness as observed by students (Keller et al., 2014), and of course, students could observe teacher's negative associations that are reflected in their teaching (Denessen et al. (2015). Our findings support previous assertions that certain teacher characteristics, in this case—PCK, SMK, enthusiasm, and temperament influence students' attitudes towards STEM subjects. It is worth noting that teachers with a positive attitude to students, good personality and passionate, who care for their teaching and for their students will have qualified students seriously considering graduate work with them (Mohamed, 2015). Likewise, secondary school students who have similar experience with their teachers will like to take on courses after their teachers. It suggests that, good STEM teachers will have students attracted to STEM courses at the postsecondary level. Teachers with adequate content-specific pedagogical preparation that is based on meaningful SMK would be able to create learning environments for their students that will in turn foster the development of students' interests, motivation and attitudes towards STEM (Even, 1993).

Lastly, we will like conclude by merging thoughts of Chan-Kredl and Colannino (2017) and Nkomo and Fagrogha (2016) who described the best teachers as those who know their subject and know how to deliver it, who possess certain personal attributes that were admired, who were caring in their encounters with the students, and had a lasting impact on the lives of their students. Conversely, the worst teachers were the ones that were unqualified, incompetent in their teaching skills, had unfriendly personality traits, were aggressive, unfair, uncaring, yells or abusive in their relationships with students, overly sensitive, had no lasting impact on the students, over reacts and totally losing the effective managerial grip in the classroom. Above all, good teachers will empower students to develop a coherent framework for their STEM ideas. To this end, it is necessary that all teachers in Bayelsa State must be taught the methodology and techniques of teaching through relevant professional development programmes in order to positively influence students' attitudes towards science, technology, engineering and mathematics as well as pursuit of STEM-related career pathways.

LIMITATIONS

While the results the study provided useful information for educators, administrators and scholars by revealing promising implications for understanding some of the affective (enthusiasm and temperament) and cognitive aspects (pedagogical content knowledge, and mastery of subject matter knowledge) of the teacher as a significant other influencing students' attitudes towards the STEM subjects, it is imperative to acknowledge that certain methodological and contextual aspects that limit the generalizability of our findings. One limitation stemmed from the total reliance on students' self-reported responses to the survey concerning their perceptions of teachers' pedagogical content knowledge, teachers' mastery of subject matter, teacher enthusiasm, and teacher temperament. Since there is no means of corroborating the students' self-reports from the teachers' perspectives, neither were there other qualitative methods like—in-depth interviews or observations, caution needs to exercise on a sole reliance on students' self-reported data. Another limitation arises from the narrow contexts on which the sample was drawn. Despite the fact that Nigeria has 36 States with an estimated population of over 200 million, it was only in one state that study was undertaken. Consequently, one should be cautious about interpreting results of this study beyond the context. It is also likely that other teacher characteristics influence students' attitudes towards a subject. Another

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concern is that our measures of teacher characteristics was one we had constructed by merely adapting the qualities of the effective teacher from the students' evaluation of educational quality (SEEQ), thus its psychometric physiognomies still need further development.

PRACTICAL IMPLICATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Despite the limitations noted above, this study contributes to the research literature on this subject and add to broaden the policy debate on STEM education. The STEM pipeline is said to be leaky and few students are said to be enrolling in STEM-related subjects at the secondary levels, and even fewer of them enrol for courses in the STEM fields at tertiary level compared to other disciplines such as—arts, humanities, law, etc. Thus, one implication of this study is that teacher characteristics should be recognised as having the potential to contribute to the development of students' positive attitude towards STEM subjects and thereby reducing the attrition rates along the STEM pipeline. After all, supporting senior secondary school students' attitudes towards STEM subjects contributes to efforts geared at teaching and retaining students in STEM related disciplines (Fulmer et al., 2019). Lastly, future research should also include longitudinal studies to understand the long-term effects of teacher characteristics on students' attitudes towards STEM subjects as well as the long term impact it has on students' willingness to pursue STEM related careers.

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