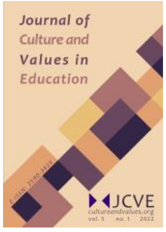

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Probing Learners' Attributes That Facilitate Effective Mathematics Teaching and Learning at the Rural Secondary School Level

Kereng Gilbert Pule[a]

a. Department of Mathematics Education, University of South Africa, South Africa.
Email: pulekg@unisa.ac.za

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ABSTRACT

This study sought to explore the attributes of students that make mathematics teaching most effective in secondary schools in the North-West province. A total of 1 120 mathematics students were surveyed with a structured questionnaire and 988 responses were received. The Statistical Package for Social Sciences was employed to evaluate quantitative responses. Study respondents were described using descriptive statistics such as the mean, standard deviation, variance and frequency distributions. According to the findings, there was a significant correlation above 0.3. The results also showed that the correlation matrix was not unitary, providing a strong relevance between the students' attributes. The p-value of most of the attributes was less than 0.01 and 0.05 levels of significance, confirming the interrelations between the attributes. Therefore, none of the attributes could be achieved without considering the others. It was concluded that the multiple relationships between these attributes are viable. Through the study, educators will be able to assess and authenticate a cross-cohort of mathematics students, which will lead to the implementation of appropriate attributes to improve mathematics performance at the secondary school level. Such diagnostic interventions can empower mathematics students to recognise warning signals to work toward improved performance.

KEYWORDS

Effective mathematics teaching; effective learning; student autonomy; student outcomes; secondary school; student attributes.

INTRODUCTION

Several theories like Vermunt’s (1992) learning styles, Gardner’s (1993) multiple intelligences and Lawrence's (1993) maintain the observed dissimilarities among students’ approaches concerning effective learning and recount the learning aspects and how these are influenced by age, gender, subject choice and character (Nielsen, 2008). The impact of effective teaching and learning on performance has been gaining attention in recent years, as has the specific student attributes that lead to better performance. Central to the entire arguments of Hattie (2009) are 800+ meta-analyses that form part of the basis of effective learning and teaching. The questionnaires for this quantitative study are based on Hattie's argument to explore the attributes of students that enable effective mathematics teaching in certain secondary schools.

The influence of effective teaching on student attainments in mathematics is crucial (Pretorius, 2013). The role it plays is significant due to its impact on what students do and how they help them overcome difficulties in performing well in mathematics (Rice, 2003). According to studies (Ball et al., 2005; Hattie, 2009; Kreber, 2002), having a solid grasp of mathematics content is crucial for educators to deliver effective teaching, making it a pivotal element of effective mathematics teaching.

Educators lacking content knowledge could result in less effective teaching, leading to negative student outcomes in mathematics. Student outcomes and efficacious mathematics teaching are not successive, sealed-off interactions, but open, ongoing processes, evolving from and interlaced in wide-ranging, often routinely integral factors in an interface within the progression of an individual, exposed, thought-provoking (Hattie & Hattie, 2022; Pule, 2020) as well as varying mathematics learning and teaching voyage as repositioned in this study.

The study focused on the following research question:

What are the attributes of students that enable effective mathematics teaching?

The secondary research questions listed below were used to answer the main research question:

- *What are some of the possible student attributes that have an impact on effective mathematics teaching in certain secondary schools?*
- *Is there a correlation between the potential student attributes that aid in the effective teaching of mathematics?*
- The purpose of the study was to examine the student attributes that aid in the effective teaching of mathematics. The study consisted of the following objectives:
- to determine potential student attributes that impact effective mathematics teaching in particular secondary schools
- to find out if there are any correlations between the possible student attributes that can aid in the effective teaching of mathematics

LITERATURE REVIEW

Effective teaching is the practice of teaching that results in improved student outcomes, which have an effect on their future success (Rice, 2013). In essence, effective learning is about collaboration between mathematics educators and their students, among students, and between the classroom and its environment (Seah, 2007). Thus, mathematics teaching and learning can a stimulating and thought-provoking role in imparting mathematical knowledge, calculations, procedures and computational techniques from educators to students (Hattie, 2009). Therefore, mathematics learning can be narrated as the acquirement of new knowledge skills and effects that are practical as well as theoretical in nature to students. Students can construct clear goals and situate these goals within learning progressions carried out from effective mathematics teaching.

Mathematics teaching is a coordinated practice of disseminating and clarifying mathematical knowledge and concepts with reflections for comprehension to the students in a classroom or centre setting (Jaworski, 2006; Pule, 2020) with a spur on intellectual and psychological widening on learning (Olo et al, 2020). Different student attributes can play a role in effective learning. Student attributes are the characteristics that students bring to the classroom (Hinze & Wiley, 2013). It explores the social upbringing of students, which includes their attitudes, cornerstone, effective group related learning methods, concerns, skill levels, past knowledge, shared viewpoints, aims, beliefs, critical arguments and character traits (Cuong, 2023; Hattie & Hattie, 2022). The effectiveness of educators' teaching can be affected by these factors in the classroom engagement of students.

The relationship between students' examination scores and their secondary school pass rate has led to their common use as a measure of educational output (Currie, 2001). The academic success of students is greatly influenced by mathematics educators who transform educational policy and curriculum objectives into learning opportunities. The outcome of a educator's effective teaching can be well represented by the average scores of the students. As a result, the typical attainment test scores of his or her students may be an artificial measure of educator effectiveness. Consequently, the test scores of students can be utilised as a measure of the effectiveness of educators.

Learning appraisals of educators are often used to assess teaching effectiveness (Currie, 2001). To assess effective teaching, students' ratings of educators' teaching can be used, and the extent of students' learning that occurs in class is considered the best principle (Hattie & Zierer, 2019). Research has revealed that students consistently have high correlations between their assessments of subject matter and their overall assessment of their educator.

As a measure of teaching performance, students' evaluation has been largely substantiated by Mohajan (2017) as being reliable and valid. According to the study, students' assessment of the value of teaching-on-learning is a reliable and accessible indicator of educator's effective teaching. Hattie suggests that students are the best source to evaluate the extent to which teaching is instructive, enlightening and worthwhile (Hattie & Zierer, 2019). Most textbooks tend to encourage students to passively accept mathematics in theory, with only slight connections between what they learn and everyday life experiences, such as pronunciations of fractions as presented in intermediate phase mathematics (DBE, 2011). The way educators interpret the mathematics syllabus influences the students' role and activities in the mathematics classroom culture. Those who possess a unified conceptual understanding of mathematics are inclined to organise their classrooms and implement learning activities that stimulate students to participate and work collaboratively with abstract mathematical concepts (Malatjie & Machaba, 2019). When students are actively engaged, the importance of teaching mathematics is closely associated with the importance of educators' mathematical knowledge.

According to Van de Walle (2016), students should be active participants in their specific learning progression, which is in line with constructivism. Moreover, students construct their knowledge. This infers that learning is self-conscious and optimised by what they know, as well as what they are thinking, saying and doing, which makes logical sense to them in connection with what they already know. It is suggested that high-performance endeavour and perpetual dedication, which are moulded by educators and students, are anchored in their pre-existing knowledge of mathematics. The cognitive level of questions in mathematics classrooms is crucial, so educators must do more than just ask questions. The likelihood of students correcting their specific errors is lower due to their hesitancy or inability to search for errors.

The primary concept of student-centred education is thoughtful reasoning. This type of education aims to make students more decisive thinkers and vigorous in their knowledge establishment (Ayanwale, 2023; Malatjie & Machaba, 2019; Pule, 2020). Cognitive schemes are sparked and inspired by thought-provoking orientation, enabling students to learn to observe/take note, relate/cross-reference, define/designate, create/conceptualise and elaborate/make easier situations. To achieve this, educators must use active methods that emphasise problem-solving, object manipulation, experimentation and group related work where students can reciprocate ideas. This would promote the development of students' mental models. These learning conditions are a consequence of cognitive development and are linked to student-centred teaching.

The concept of student autonomy is that students are active participants in the learning process and take responsibility for their own learning (Doolittle, 2014). This non-reductionist approach uses an all-inclusive lens that stresses learning in the classroom. The incorporation of student autonomy as well as an all-inclusive angle puts constructivism as the combination of beliefs (Doolittle, 2014). Different categories of learning vary from the main assumption of education, based on the surroundings which may consist of active learning opportunities for students. This may also include the actual environment, students' thoughts on possession, responsibilities and options, as well as their feelings towards effective teaching and learning.

Effective teaching and learning take place when learning is an unequivocal aim when it is fittingly thought-provoking when the educator and the student in their different ways want to make sure to what angle the challenging goal is obtained (Hattie, 2009). Hattie maintains it happens when a thoughtful practice is aimed at achieving mastery of a goal, while there is feedback set and required, as well as when there are dynamic, passionate and interactive participants like educators, students and peers contributing to the deed of learning. The educator sees learning through the eyes of students, and students see teaching as a key to their continuing learning. The notable piece of evidence is that the major effects on learning take place when educators turn into students of their specific teaching, and when students turn out to be their educators. When students turn out to be their educators, Hattie found that they show self-regulatory attributes that appear most desired for students (self-assessment, self-evaluation, self-monitoring and self-teaching). Thus, it is effective teaching and learning by educators as well as students that marks the change. Teachers have a vital role to undertake in generating a learning experience that will allow better teaching and learning through correlated attributes enhancing students to comprehend some elementary mathematical concepts (Saleh et al., 2018). Nonetheless, the learning efficiency is shaped by what learners agreed upon with the capacity to retain what was taught as a result of the combination of the attributes under study.

THEORETICAL FRAMEWORK

The constructivist theory of learning was drawn upon to understand mathematics learning and to emphasise the students' capabilities and interests. The theory is seen as an operation in which the student builds meaning by reshaping new enquiry into their prevailing knowledge through the mainstreaming and reinsertion of competence (Krahenbuhl, 2016). Constructivist strategies in mathematics also emphasise the solving of problems as one of the learning forms (Akpan & Beard, 2016). One way of working with the nature of problem-solving is to analyse what a problem is all about. A problem may come up when one is challenged with something one does not know how to handle. That suggests that if one already knows the procedure for finding a solution to the problem, then there is a way. Problem-solving can be considered as an order of cognitive actions focused on a goal. These actions embrace the unknown and the known techniques.

The techniques that are known are based on personal experiences, but the unknown is based on circumstances. The ability to find or solve mathematical problems requires open instruction in problem-solving techniques. Investigation and metacognitive approaches are employed to comprehend the problem, create or develop a plan, execute the plan, and reflect. Discovering the challenge, interpreting the problem, developing effective strategies and being in a position to reflect on the solution are crucial. Constructivist teaching has hypothetical and epistemological assumptions as outlined by Carson (2005). It is worth noting that real life hinges on the individual perceptions of it and therefore created. The science of reasoning is not the only mechanism for comprehending the real world. However, it is one of few, and the cognisance of the real world is personal as well as related to a single person or community of students.

It is common for students to build their understanding of knowledge by gaining insight into their real-life experiences. In other words, knowledge is actively created by students (Fleury, 1998). To put it differently, students actively create knowledge (Fleury, 1998). It's clear that students generate their own knowledge and conceptual understanding owing to their engagements. The educator's responsibility is to establish a favourable learning atmosphere for mathematics, which will improve students' aptitude to generate their mathematical knowledge. The positive atmosphere would allow students the opportunity to connect their understanding, declare assumptions, utilise their resources, and investigate with their reasoning towards the construction of mathematical knowledge.

RESEARCH METHODOLOGY

Research design

A quantitative approach was employed in this study. Effective teaching of mathematics was the dependent variable. The independent variables were continuous data because they have a plethora number of values in a continuance. The independent variables acted as determinants (see table 3). Independent variables as “predictors” (antecedents) and dependent variables act as “criterion” (predicted) variables in non-experimental research, such as in this article (McMillan & Schumacher, 2010). The close-ended survey questionnaires have been used to find patterns and averages, make predictions, test casual relationships, and generalise results on students' attributes that facilitate effective mathematics teaching and learning. This article investigated how the dependent variable are affected by independent variables (Olubela, 2015). The research design investigated the interrelationships between variables. It gave the bearing of a relationship among two or farther variables. The interrelatedness can have either a positive or negative influence, both significant and non-significant, indicating the design's versatility (Adu & Duku, 2021).

Sampling

From the 25 secondary schools in the Mahikeng sub-district of the North West province in South Africa, six secondary schools were selected for this study. The six selected secondary schools include three highly effective schools and three less effective schools based on Grade 12 results. The highly effective schools are schools that have been performing above 80% in Grade 12 final centralised examinations for over five years, whereas less effective schools are schools that are constantly performing less than 60% for more than five years. The study's target audience was 602 mathematics students in Grade 11 and 518 mathematics students in Grade 12 in the selected secondary schools. Grade 11 mathematics students were chosen as participants because they are in the pre-exit level of Further Education Training (FET) and believe that they can clarify some matters related to mathematics students in their schools. The Grade 12 students were involved because they were senior students and the most experienced students in the selected regarding matters around mathematics teaching and learning. The total number of participants was 1 120 as shown in table 1 below.

Table 1.

Sample overview

Participants	Number of participants	Total
Grade 11	602	
Grade 12	518	1 120

The validity and reliability of the questionnaire

The questionnaire's units were developed to test the items they intended to measure. The accuracy and reliability were validated and verified by the author through a pilot study. The Likert scale questionnaire was used to compute Cronbach's alpha to confirm the reliability of its units. After that, the determinants of effective mathematics teaching in Mahikeng sub-district secondary schools were established with reliability. Cronbach and Shavelson (2004) suggested a commonly accepted rule to describe internal consistency, which was adopted by the study. If there is a deviation from 0.7 to 0.8, then internal consistency is considered acceptable. The internal consistency of the instrument used was measured using a benchmark of 0.7 due to the sample used in this study. From 41 items out of 988 responses, Cronbach's alpha was calculated to be nearly 0.9, with a value of 0.869. Cronbach and Shavelson (2004) advise against relying exclusively on the alpha coefficient to determine reliability. While it's a useful indicator, the standard error of the KMO can be increased, and so other measures should be considered when investigating reliability. Other statistics can also be beneficial, as stated by Cronbach and Shavelson (2004). Estimated variances calculated above can help pinpoint areas where a test may be struggling. If the alpha calculation is restricted by a solid residual, then the predictor may conclude that the respondents are being scored in diverse ways, which implies a significant correlation between the respondents and the test (Montshiwa & Moroke, 2014). An investigative tool that supplements the data acquired when compared to running an objective alpha coefficient can be a valuable resource for confirming internal consistency in a test without confirming internal consistency.

Data analysis

The use of descriptive statistics and inferential statistics is common when analysing quantitative data. Pearson's correlation coefficients were used to establish a correlation between the student attributes and effective mathematics teaching in Mahikeng sub-district secondary schools.

The study's suggested statements were analysed through exploratory factor analysis to determine whether students agreed or disagreed. According to Field (2013), obtaining unwavering standard errors and accurately reflecting the actual population can be achieved by using a large sample factor analysis. The importance given to this viewpoint is expressed by Costello and Osborne (2005) and Tabachnick and Fidel (2012). Comfrey and Lee (1992), who were cited in Tabachnick and Fidel (2012), recommended that the sample size be determined by the following criteria: 50 is sub-standard, 100 is inadequate, 200 is fair, 300 is objective, 500 is magnificent, and a minimum of 1 000 are outstanding. Tabachnick and Fidel (2012) apprise that the sample size required for a reliable underlying construct should be between 200 and 400 due to the decreased reliability correlation coefficients between the variables due to small samples. Therefore, the sample size of 1 120 in this study is excellent.

The initial step was to investigate the data for adequacy, as factor analysis heavily relies on a large sample size. In light of this, the study utilised the Kaiser Meyer-Olkin (KMO) as a benchmark of sample adequacy before conducting the exploratory factor analysis. To ensure the validity of factor analysis, Bartlett's test of sphericity must have a value below 0.05.

According to the literature, factor analysis requires KMO values greater than 0.5 but not exceeding twice this value. The pattern of the correlation matrix is a topic of contention between authors. According to Field (2013), if the value is closer to one, it implies that the correlation pattern is reasonably compact, indicating that factor analysis would produce factors that are diverse and consistent (Montshiwa & Moroke, 2014). To make a decision on the suitability of the sample used, this study used Kaiser's (1974) rule of thumb. The KMO range is characterised by 1 to 0.9 being marvellous, 0.8 and 0.89 being meritorious, 0.7 to 0.79 being middling, 0.6 to 0.69 being mediocre, 0.5 to 0.59 being miserable, and 0 to 0.49 being unacceptable. In addition to Bartlett's test of sphericity, the Kaiser-Meyer-Olkin measure of sampling adequacy is utilised. Bartlett's test was employed to examine whether the variables used in the analysis could be factored. The hypothesis being tested is that the correlation matrix is derived from a population with an identity matrix and correlations that are not zero. The data will yield diverse factors only if the hypothesis is rejected with significant significance at or below 5%.

Reliability analysis

The study analysed internal consistency through a rule of thumb that was widely accepted. This rule was equally pointed out by Kline (1999) as well as Cronbach and Shavelson (2004), which is implementable as follows: if $\alpha \geq 0.9$ is exceptional, $0.8 \leq \alpha < 0.9$ is brilliant, $0.7 \leq \alpha < 0.8$ is satisfactory, $0.6 \leq \alpha < 0.7$ is arguable, $0.5 \leq \alpha < 0.6$ is inadequate and $\alpha < 0.5$ is unsatisfactory. A 0.7 benchmark was used to measure the internal consistency of the instrument used because of the sample used in this study. Cronbach's alpha was calculated to be 0.869, which is nearly 0.9, for 41 items from 980 responses.

Cronbach and Shavelson (2004) recommended that relying solely on the alpha coefficient to determine reliability can be misleading. Although it is a valuable measurement, the standard error of the KMO can be increased, so additional measurements should be considered when exploring reliability. Other statistics can also be beneficial, as stated by Cronbach and Shavelson (2004). Estimated variances calculated above can help pinpoint areas where a test may be struggling. For instance, if a solid residual restricts the alpha calculation (i.e., lowers it), then the predictor may deduce that there is an exceedingly large relation between the respondents and the test (i.e., respondents are being scored in diverse ways). A diagnostic tool that adds to the data acquired when compared to running an objective alpha coefficient can be a valuable resource for confirming internal consistency in a test without confirming internal consistency. The researcher was able to draw conclusions from the reliability analysis procedure about the relationships between the student attributes used in this study.

RESULTS AND ANALYSIS

The study aimed to obtain feedback from students about the attributes that encourages effective mathematics teaching. The analysis of students' responses is the topic of discussion in this section based on empirical results. To create indicators of effective mathematics teaching, the student data were primarily collected. The KMO test is described using the results depicted in table 2 below.

Table 2.

KMO test

Kaiser-Meyer-Olkin measure of sampling adequacy	0.830

Table 3.

Bartlett's test

Bartlett's test of sphericity	
Approx. Chi-Square	3970.142
Df	820
Significance	0.000
Determinant of matrix	2.270E-6

The sample used is meritorious based on the results presented, and it ranges from 0.80 to 0.89 in table 2 with the value of 0.830. The sphericity test was rejected, indicating that it is adequate, and the matrix is not unique. The non-singularity of the factors is confirmed by the fact that the determinant of a correlation matrix is not equal to zero. As the test revealed a value of 0.000 in table 3, factor analysis was found to be appropriate. Hence, the data are expected to contain diverse factors. According to Cronbach and Shavelson (2004:395), the instrument used for data collection is appropriate. The results of the suggested exploratory factor analysis of 41 items in this study suggest a reliable statistic of 0.869, which confirms these findings.

This section contains the results of the factor rotation. The factor structure is simplified by factor rotation, but it still allows for interrelated factors. Norusis (1994) recommended interpreting the factors through the use of correlation coefficients. In table 4, the first secondary question is addressed through the empirical results of studies presented below. As stated by Mavetera et al. (2015), quantitative studies rely on high-quality data, and the data presented should be presented in an acceptable format. To assess their agreement or disagreement with the attributes they identified with, students were asked to rate them. Table 4 below shows that students have a positive response to the attributes that impact effective mathematics teaching.

Table 4.

Student attributes

Attributes	Variances
Self-perception on mathematics	7.689
Attitudes concerning mathematics	2.945
Self-assessment	2.345
Independent learning	2.171
Affinity to educators	1.835
Learning repertoire	1.308
Orientation to learning	1.200
Student-educator support material	1.170
Adjustment to school	1.143
Parental support	1.074

The author 's ten attributes have been suggested by the author, and according to the results presented in table 4, the general impression is that respondents agree with them. The general significance of the correlation coefficients for the rotated attributes indicates that students either agree or strongly agree about these factors. There were fewer respondents who held different views, resulting in a lack of or poor convergence in certain factors, such as independent learning, where students had conflicting opinions about their involvement in mathematics group related work and conducting independent mathematics research activities (Mercer & Sams, 2006:507). It is possible that some mathematics students value the culture of collaborative learning during teaching, which could have a positive impact on their performance.

Different opinions were expressed by some students regarding the learning repertoire. They think that mathematics lessons are boring because their educators do not use innovative teaching methods. Students voiced their dissatisfaction with support structures and resource shortages caused by vandalism and theft. Mathematics remains abstract without resources, as found by Makgato and Mji (2006). The divergence of each of the ten attributes was confirmed by calculating their variances. After factor rotation was used, the attributes showed less correlation and were different than expected. It is evident that most students' responses correlated more closely with their self-perception of mathematics, affinity towards educators, orientation to learning, and parental support (Hattie & Hattie, 2022, Cuong, 2023).

The ten attributes that were highlighted are crucial to the students' learning of mathematics. Schools should prioritise self-perception in mathematics, as confirmed by their responses. This attribute has a greater variance than other attributes. Attitudes toward mathematics, self-assessment and independent learning are the three most significant attributes that students highlight, with variances of 2.945, 2.345 and 2.171 respectively. Despite receiving lower variance ratings than others, other factors are still significant. It can be concluded that the ten attributes can be utilised as learning attributes to enhance students' mathematics performance in the chosen schools. The empirical results of the study are presented in table 5 to answer the second secondary question.

Table 5.

Correlation matrix

Keys: A - self-perception; B - attitudes concerning mathematics; C - self-assessment; D - independent learning; E - affinity; F - learning repertoire; G - orientation to learning; H - student-educator support material; I - adjustment to school; J - parental support

	A	B	C	D	E	F	G	H	I	J
A	**1**	-1.0	0.887	1.000	-2.41	-1.00	0.054	1.000	0.670	-0.78
B	-1.00	**1**	-1.00	-1.00	-1.00	1.00	-1.00	-1.00	1.00	1.00
C	0.887	-1.0	**1**	1.000	-0.32	1.00	0.921	1.000	0.957	0.53
D	1.000	-1.0	1.000	**1**	1.000	-1.00				
E	-0.24	-1.0	-0.32	1.000	**1**	-1.00				
F	-1.00	1.00	-1.00	-1.00	-1.00	**1**				
G	0.054	-1.0	0.921	1.000	0.308	-1.00	**1**			
H	1.00	-1.0	1.00	1.00	1.00	1.00	1.00	**1**	1.00	-1.00
I	0.670	-1.0	0.957	1.000	0.265	-1.00	0.746	1.000	**1**	-0.69
J	-0.78	1.00	0.53	-1.00	-0.39	1.00	-0.09	-1.00	0.69	**1**

The flexibility of the design can be reflected in the interrelationships, which can be negative or positive, and can be neither significant nor significant (Adu & Duku, 2021). The correlation matrix in table 5 has rows and columns representing attributes, and the correlation between them is displayed in the cells. Each cell has values that reflect the strength and orientation of the correlation, with some being positive and some being negative (Olubela, 2015). The closer the value is 1 (or -1), the stronger the correlation. A positive correlation signifies that there is a direct link between two variables, with both variables moving in the same direction (e.g., when one attribute increases, the other also increases). A negative value indicates negative correlations implying that when one attribute increases, the other attribute tends to decrease. It should be noted that there are no values in some cells signifying that there is no correlation between the two attributes.

In each row, there is a visible entry of 1 (one) that is to the right of the row immediately above it. The suggestion is that the system is dependent because there are an infinite number of solutions in the matrix (Cronbach & Shavelson, 2004) and the linear combination of factors (Montshiwa & Moroke, 2014:356). The inter-related correlation matrix population is the source of these attributes, which indicate their interrelationship (Hattie & Zierer, 2019). It can be concluded that effective mathematics teaching may be supported by multiple correlations between student attributes to be in position solve their mathematical problems (Akpan & Beard, 2016; Saleh et al., 2018). The article found out that the attributes under investigation are appropriate to improve performance of students who take on mathematics. The inference of this is that teachers need to acknowledge these attributes and harmonise these attributes with students for effective teaching and learning to produce considered necessary improved outcomes.

CONCLUSION

The study's conclusions were successfully analysed within its limits and responded to the fundamental unit of inquiry. The purpose of the question is to encourage mathematics educators to stimulate students' curiosity and teach mathematics effectively, and to regularly examine the attributes of the student cohort. The efficacy of diagnosing effective mathematics teaching using the identified attributes could be done continually as a work-in-process to complement this study.

This study findings are limited to the validity of factors and the correlation between the attributes. It requires continuous evaluation to achieve effective mathematics teaching, as evidenced by the research findings mentioned above. Finally, evidence suggests that the ten attributes have a mixture of significant relationships, both positive and negative. It's clear that the correlation matrix is not unitary, leading to strong correlation between the attributes of the ten students. This reinforces the viability of the multiple relationships between these student attributes, which influence effective mathematics teaching. This paper reports research that can be used to facilitate effective mathematics teaching and learning, especially in rural schools. More insight into the literature regarding student attributes that facilitate effective mathematics teaching in South Africa can be gained from the reported findings.

Nonetheless, the study will enhance educators to assess and authenticate cross-cohort of mathematics students, hence implementing suitable attributes to improve mathematics performance at the secondary school level. Such diagnostic interventions can empower mathematics students to recognise warning signals to work toward improved performance.

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