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## Teaching methods that influence Grade 12 students' mathematics results in Port Moresby, Papua New Guinea

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Mathematics education;  
Papua New Guinea;  
student-centric teaching;  
teacher-centric teaching.

### Abstract

Teachers' teaching methods are important as they have been shown to determine the students' mathematics performance at secondary schools. However, it is evident that a significant number of students cannot continue to Grade 11, and there is a simultaneous decline in student enrolment in science-related degrees at the university level in Papua New Guinea (PNG). That being the case, this study aims to examine teaching methods employed by teachers in the classroom that affect Grade 12 students' mathematics results. A mixed method research (qualitative and quantitative) approach is applied in this study. The interview data for Grade 12 mathematics teachers were analysed through a thematic approach to capture rich information. Three different teaching methods (teacher-centered, student-centered, and a mix of both teacher-centered and student-centered approaches) are identified in this study. It is evident in this study that the student-centred method has a significant influence on Grade 12 students' mathematics results. The study concludes that more attention should be given to student-centered and mixed approaches, in order to improve Grade 12 students' mathematics results.

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## Introduction

The primary purpose of teaching at any level of education is to bring about a fundamental change in the learner (Senthamarai, 2018; Tebabal & Kahssay, 2011). Teachers should apply appropriate teaching methods to facilitate the process of knowledge transmission that suits best the specific objectives and outcomes. Traditionally, many teachers have widely applied teacher-centered methods to impart knowledge to learners comparable to student-centered methods (Senthamarai, 2018; Saeed et al., 2019). However, the arguments about the effectiveness of different teaching methods on student learning are consistently raised with considerable interest in educational research (Ardeleanu, 2019; Senthamarai, 2018). Moreover, research on teaching and learning constantly endeavours to examine the extent to which different teaching methods enhance growth in student learning.

The decline in academic performance of the students is fundamentally linked to the application of ineffective teaching methods by teachers to impart knowledge to learners (Borgonovi et al., 2021; Morsy et al., 2018). According to Ardeleanu (2019), teaching is a process that involves bringing desirable changes in learners so as to achieve specific outcomes. In order for the teaching methods used to be effective, the teachers need to be aware of numerous teaching strategies to assist students to learn better (Senthamarai, 2018; Saeed et al., 2019). Many researchers argue that teaching strategies such as student- and teacher-centered methods have improved academic performance for students (Kahramonovna, 2021; Murphy et al., 2021; Precious & Feyisetan, 2020). Other studies have also claimed that integrating both approaches has a significant influence on the students' academic results (Bralić, & Divjak, 2018; Trinidad, 2020). Therefore, the three teaching approaches are discussed further in the literature review below.

## Literature review

The teaching method is the mechanism that is used by the teacher to organize and implement a number of educational activities to achieve certain goals (Bieg et al., 2017; Ardeleanu, 2019). Teaching techniques are the means that reflect the success of the learning process and the competencies of the teacher (Malik & Masri, 2019; Voskoglou, 2019). For instance, from the author's teaching experience, teachers often look for new ways to deliver knowledge to the learners, and on many occasions, discovered that traditional teaching methods become not effective as they used to be due to the current advancement in technology. Teaching becomes more effective when it is performed in a quicker response to the needs of the learner. A teaching method is comprised of the principles and methods used by teachers to enable student learning (Senthamarai, 2018; Saeed et al., 2019). These strategies are determined partly by subject matter to be taught and partly by the nature of the learner. For a particular teaching method to be appropriate and efficient, it has to be in relation to the characteristic of the learner and the type of learning it is supposed to bring about (Valizhanovna, 2022; Revikovich, 2022; Voskoglou, 2019). Studies suggest that the design and selection of teaching

methods must take into account not only the nature of the subject matter but also how students learn (Ardeleanu, 2019; Asghar et al., 2019).

The teacher-centered method encourages the students to focus completely on the teacher in the classroom (Bremner, 2019; Di Biase, 2019). Studies claim that the teacher is the focus, and he/she does almost all the talking while students continue to listen and remain silent (Al-Balushi et al., 2020; Case, 2019; Montrieux & Schellens, 2018). The collaboration between teacher and student is minimal in teaching and learning in the classroom. A study by Bergström and Wiklund-Engblom (2022) in Finland reveals that the full control and authority of the learning activities in the classroom rests on the teachers. Therefore, the classroom is often orderly, and students remain quiet. Furthermore, a study by Wheaton (2021) states that as the teacher designs, directs, and conducts all classroom activities under his or her supervision, it reduces the chances of the students missing any important material or content.

However, several studies argue that this approach to education can hinder the communication and collaborative skills of students, as students often work alone (Baghoussi, 2021; Teppo et al., 2021; Fatima, 2022). Moreover, continuous teacher-centered instruction can create a monotonous nature inside the classroom, and this may make students feel bored with their studies. A study by Bature (2020). supports this argument and claims that a teacher-centred approach may become less powerful in capturing and maintaining the student focus in the lessons. Most significantly, other studies also reveal that a teacher-centered approach inside the classroom prevents learners from expressing themselves and discourages them from asking questions and logical engagement in self-learning (Olatunde-Aiyedun & Ogunode, 2020; Uzunboylu & Özcan, 2019).

In teacher-centered classrooms, control is of primary importance, and "authority is transmitted hierarchically" (Dollard & Christensen, 1996, p. 3). This indicates that the teacher exerts control over the students' learning in the classroom. Studies on teacher-centered teaching argue that in these classrooms, compliance is valued over initiative and passive learners over active learners (Kakongoro, 2019; Mugizi et al., 2020; Yao & Collins, 2019; Shipton, 2020). Teachers control the students' learning with instructional methods that promote them as the focus by using lectures, guided discussions, and demonstrations (Kakongoro, 2019; Mugizi et al., 2020). A study by Bature (2020). claims that these forms of instruction enable the teacher to stand in the front of the classroom while all students work on the same task. In addition, the physical design of the classroom often promotes a focus on the teacher and limits student activity that disrupts the focus of the learning (Bature, 2020; Yao & Collins, 2019). In other words, the classrooms are often organized so that desks face toward the primary focal point, the teacher.

Moreover, in teacher-centred teaching, teachers exert their control through a system of clearly defined rules, routines, and punishments that are mandated rather than developed with the students (Kakongoro, 2019, Mugizi et al., 2020). Studies reveal that teachers identify the rules necessary

for learning in the classroom (Bature, 2020; Kakongoro, 2019; Mugizi et al., 2020). In teacher-centered classrooms, teachers may rely on extrinsic motivation to influence student behavior for learning to take place. This teaching method allows students to learn, and the process is seen as a prerequisite for obtaining something desirable (Yao & Collins, 2019; Shipton, 2020), such as social rewards (e.g. praise), activity rewards (e.g. free time, computer time), and tangible rewards.

Unlike in a teacher-centered teaching method, in a classroom that uses a student-centered approach, both teachers and students share an equal focus (Wang & Zhang, 2019; Ali, 2019). Most significantly, a higher level of student-teacher interaction is visible in a student-centered approach. Studies reveal that students do not play the role of excessive listeners; instead, they learn to collaborate with each other (Ali, 2019; Benlahcene et al., 2020; Arman, 2019). Furthermore, research suggests that this approach highly encourages teacher-learner communication.

Several studies confirm that the student-centred method allows learners to acquire collaborative and communicative skills mainly through group work (Gezim & Xhomara, 2020; Muganga & Ssenkusu, 2019). In addition, it gives learners the freedom to acquire knowledge independently and logically by asking questions. Inside a student-centred classroom, learners are relatively more enthusiastic in the learning process due to the high interaction with one another and also with the teacher (Dakovic & Zhang, 2020; Murphy et al., 2021). However, unlike the strict and orderly nature of the teacher-centred classroom, student-centred classrooms can often get chaotic and noisy (Jacobs & Renandya, 2019; Sandybayev, 2020). Further, students possessing varying learning styles and speeds and managing all students' activities at once can get comparatively harder for the teacher (Jacobs & Renandya, 2019). Despite that, teachers act as facilitators to guide the students to take ownership of their own learning to discover new ideas and knowledge. For instance, several studies claim that student-centred methods are of interest primarily in assisting students to engage with problems and issues, search below the surface, try out various possible solutions or explanations and finally construct their own meaning (Jacobs & Renandya, 2019; Sandybayev, 2020; Precious & Feyisetan, 2020). A study by Wulf (2019) discovered that the teaching methods or strategies include reflective thinking, inquiry, exploratory discussions, role-playing, demonstrations, projects, and simulation games. These teaching strategies empower students and strengthen their sense of responsibility.

The development of interpersonal relationships is an essential component of a student-centred approach, since positive student-teacher relationships presumably reduce the need for control and become the foundation for all interaction in the classroom (Bechter et al., 2019; Talbert et al., 2019). The student-centered environment facilitates a more collaborative way for students to learn. Studies indicate that the teacher models instructions and acts as a facilitator, providing feedback and answering questions when needed. A study by Komatsu et al. (2021) highlights that the students choose how they want to learn, why they want to learn that way, and with whom. Students answer

each other's questions and give each other feedback, using the teacher as a resource when needed (Bechter et al., 2019; Talbert et al., 2019).

Moreover, in a student-centred approach, teachers minimize the use of extrinsic rewards because they may adversely affect student motivation, create reliance on the teacher, and encourage appropriate behavior for the sake of a reward rather than for the good of the learning (Talbert et al., 2019; Aytac & Kula, 2020). Instead, teachers are encouraged to use strategies for enhancing a student's intrinsic motivation (Duraisingh, 2020), including adapting activities to students' interests, calling attention to the instrumental value of academic activities, incorporating game-like features, and providing opportunities to exercise autonomy and make choices.

A teaching methodology that strategically combines both teacher- and student-centered approaches can foster the benefits of both of them. Indeed, this seems to be supported in a study of students' conceptions of the effectiveness of different learning environments, which reveals clearly the students' preferences for methodologies based on content and expository teaching (Muganga & Ssenkusu, 2019; Richards et al., 2019). Additionally, Rapanta (2021) emphasises that efficiency of teaching methods is increased by combining student-centred methods with those that are based on teachers' explanations (lecture-style classes). Studies also support that combined methods that encourage both students' and teachers' collaboration make a key contribution to the effectiveness of their learning (Muganga & Ssenkusu, 2019; Richards et al., 2019; Talbert et al., 2019; Aytac & Kula, 2020). In this sense, it appears to be supported that adequate explanations by the teacher that stimulate students' active participation facilitate the mental and emotional atmosphere that is necessary to create an environment that is conducive to deep learning (Bechter et al., 2019; Talbert et al., 2019). Many authors highlight that methodologies based on projects and problem-solving promotes higher-order cognitive activity in the students (Talbert et al., 2019; Aytac & Kula, 2020).

Importantly, teaching is a pragmatic job, and teachers do their best to facilitate learning in the classroom (Revikovich, 2022; Valizhanovna, 2022). Students need to learn facts, principles, standard procedures, or ways of doing things before they can start an informed discussion about their meaning and before they can start solving problems (Revikovich, 2022; Voskoglou, 2019).

The study aims to identify the specific teaching methods that influence Grade 12 students' mathematics results. The guiding research question for this study is: What teaching methods influence Grade 12 students' mathematics results in Port Moresby, Papua New Guinea?

## Methods

This section of the paper discusses the methods and procedures used to collect and analyse the interview data. In this study, both qualitative and quantitative research methods are applied. The qualitative method increases the

understanding of the underlying phenomenon (Creswell, 2002; Creswell & Creswell, 2017), while quantitative approaches provide valuable information (through rigorous treatment of data) to address the research problem (Creswell, 2008; Creswell & Clark, 2007; Onwuegbuzie & Leech, 2006).

### **Development and administration of interview questions**

The interview questions were developed following basic guidelines (Archibald, 2016; Bamberger, 2012; Creswell, 2008). Each question was constructed with reference to the topic and the purpose of this study. Accordingly, the brevity and clarity of the instrument were prioritised. Biased and negative wordings that may have influenced teachers' responses were avoided. The questions developed were then discussed with three experienced teachers. Feedback from these researchers related to designing the questions on the quality of teaching aspects adapted from the teaching quality model in schools in New South Wales, and how the researcher would engage teachers to truthfully express their feelings towards teaching mathematics. Consideration of validity and reliability were paramount for interview questions for the teacher participants (Archibald, 2016; Creswell, 2008). As this paper aims to get Grade 12 mathematics teachers' views about their methods of teaching mathematics. Grade 12 teachers are selected in this study because their students sit for PNG national examination each year. The results of these examinations continue to decline over the years, and many students cannot go to universities and colleges, respectively. Ethics approval was obtained from the University of Adelaide's Human Research and Ethics Committee (UAHREC Ethics Approval No H-2017-133).

Mathematics teachers of Grade 12 students were selected. Teachers were purposefully selected with a mixture of experience, from expert and novice, to ensure that a balance of views and opinions was received (Creswell, 2002, 2017). Semi-structured interviews were scheduled during teachers' non-contact periods, and the interviews were conducted in the English language. Once the appointments were made, interview questions were provided to teachers, in order to obtain as honest and detailed answers as possible. Interviews were then conducted in 16 schools, with 21 teacher participants. Ten female and eleven male teachers participated in the study. The schools were selected according to accessibility and availability of participants. Catholic, government, and private schools were selected equally, according to their location. Participants were informed that the interviews were to be audio-recorded. Prior to the interview, the researcher explained to participants the purpose, importance, and confidentiality of the interview (Creswell, 2008). After that, the researcher began to ask questions using the interview protocol. Questions were rephrased, and examples were highlighted relating to scenarios for the participants to understand the questions. At the end of the interview, the researcher thanked the participants and reassured them of the confidentiality of their responses.

### **Thematic analysis approach**

NVivo 12 software was used to analyse the interview data in this chapter. NVivo is a data management tool (Hart & Achterman, 2017), that organises and assists in making sense of data during analysis (Hamrouni & Akkari, 2012; Hart & Achterman, 2017). NVivo organises, stores, and retrieves data more efficiently than manual methods, saves time, and helps to rigorously back up findings with evidence (Hamrouni & Akkari, 2012). The data were imported from a text file and analysed with NVivo's visualisation tools. The software allows the researcher to classify, sort, and arrange information; examine relationships in the data; and combine analysis with linking, shaping, searching, and modelling (Hamrouni & Akkari, 2012; Hart & Achterman, 2017). The researcher can test theories, identify trends, and cross-examine information in a multitude of ways using the software's search engine and query functions.

Thematic analysis is the most common analysis approach used in qualitative research. This approach emphasises pinpointing, examining, and recording patterns (themes) within data. Themes are patterns across data sets that become the categories for analysis and are important in describing a phenomenon associated with a specific research question. In this approach, themes are used to capture the essence and spread of meaning; they unite data that might otherwise appear disparate, and correct meanings that occur in multiple and varied contexts. "Thematic analysis can be an essentialist or realist method, which reports experiences, meanings and the reality of participants" (Braun & Clarke, 2006 p. 81). Therefore, thematic analysis works both to reflect reality and to unpick or unravel the surface of 'reality'.

In this study, thematic analysis is performed following the six processes of coding phases outlined by Kvale and Brinkmann (2015) and Braun & Clarke (2006) to create established and meaningful patterns. The first step is familiarisation with the data to sort out ideas through transcribing, reading, and re-reading. Second, codes are generated in a systematic approach across the entire data set, in order to collate data that are relevant to each code. Third, themes are identified for coding, and to gather the data for each relevant and potential theme. Fourth, these themes are reviewed to ascertain that they work in relation to the coded extracts and the entire data set, to generate a thematic 'map' of the analysis. After that, the themes are defined and named to tell a clearer story of the data. Finally, a scholarly report of the analysis is produced that relates back to the research question and literature. These six steps to analyse the quantitative data using the thematic approach were organised and expedited through the use of the NVivo 12 software. The qualitative responses from the themes were arranged in frequency tables to apply quantitative methods in the analysis for the three teaching methods (student-centred, teacher-centred, and both methods combined).

### **Results and discussion**

This section highlights each of the main themes and their sub-themes that were identified in the data by frequency analysis of the teacher-level interviews. The key theme



that emerged from the data analysis is teaching methods (student- and teacher-centred methods). This theme seems to have an influence on the mathematics outcomes of students. Therefore, the interview results related to the teaching methods of teachers will shed more light on how teaching affects Grade 12 students' mathematics results.

## Teaching methods

The kind of teaching approach employed by teachers can have an impact on students' mathematics learning in the classroom. This is evident in the mathematics teachers' responses, in which they report using different methods in delivering their mathematics lessons. It was clear from the responses that either traditional (teacher-centred) or student-centred teaching methods are the approaches most often used to teach mathematics at schools in Port Moresby. However, there are a few teachers that apply both teaching methods in the delivery of their lessons. These teaching strategies are now discussed separately to present a deeper understanding of how they affect students' mathematics results.

### Traditional (teacher-centred) method

The interview analysis revealed that most teachers use traditional methods to deliver their lessons. In other words, the teachers are verbally explaining the mathematics concepts/ideas using a blackboard and/or textbooks, handouts, worksheets and charts. This suggests that these teachers are more dependent on writing notes from textbooks on the blackboard, verbally explaining the mathematics ideas, and giving handouts to assist students in exercises and activities. One of the teacher participants said:

I use two basic methods. A) use the normal method using blackboard. I stand at the front, write down the topic, introduce topic briefly and use examples on the board. The main method used. B) issuing textbooks and handout. They have the resource with them, write topic, give the example there on the board, and tell them you have the example in the textbook or handout you have. [Teacher 4]

Another teacher participant highlighted that charts and visual aids assist to verbally explain the main points with examples in the lessons, and noted that they give exercises to the students derived from these resources. This implies that these teachers are not providing guidance to students individually, but instead are using a lecture approach similar to a higher education setting. The teacher participant highlighted that:

When I go to class, I use chart or visual aid and stick them on the blackboard. Put up the main points and explain them to the students. After discussing the main points, I explain and go through the examples. Then I tell the students to do the activities. It's like lecture type. [Teacher 10]

Interestingly, another teacher participant mentioned the specific step-by-step strategies they employed in the classroom and identified their own approach as a teacher-centred method. This method includes giving out handouts to students, with verbal explanations carried out on the blackboard. However, the effectiveness of the handout method was not explained in detail by the participant. The teacher participant said:

Firstly, I provide notes in the form of a handout, all the explanations, especially examples and exercises are on the handout. While they are looking through the handout, I explain to them. When I am explaining, I go through the same examples in the handout on the blackboard because this is mathematics, and sometimes they might not understand what they are reading. So, I have to do it on board by writing them again, explain the maths problems step by step. [Teacher 14]

Another teacher participant remarked that the explanation of details with examples assists students in understanding and practicing mathematics exercises. Within this method, more practice exercises are therefore encouraged for students to better understand mathematics ideas. The teacher participant stated that:

Before I give the activities, I explain and I have to go in detail explaining the examples. They have to understand first before I give them exercises to do. First, I give the practice exercise and once they are done, I give them allocated time for these practice exercises. That is to see whether they understand the examples given. [Teacher 7]

Similar to teacher participant 4, a great deal of dependency on textbooks and worksheets is evident in teacher participant 9's method of teaching. This teacher feels comfortable with providing summarised worksheets to students so that they can follow a set method employed in response to challenges, as there is a shortage of textbooks at the school. This particular teacher highlighted that, with this method, lessons become more teacher-centred and students are not actively involved, as they get confused working by themselves. The teacher participant emphasised that:

Just textbook alone. Teaching with the textbook is the old passion, ah, but teachers need to be more prepared, ah. It's the preparation part that always makes the teaching of mathematics more interesting. It's the interest, ah, how you prepare and present the lesson. Now teachers tend to use textbooks more than producing work. It's like what is prepared in the textbook is what is taught. [Teacher 9]

Another teacher participant said:

Like you mean chalkboard. For that, we're using especially... chalkboard sometimes and textbook. But we do not have plenty of textbooks. We're just using handouts, duplicating handouts from textbooks. Sometimes we use charts to write our notes on paper so that students can copy the notes, examples, and exercises on charts. We use these methods. [Teacher 2]

One of the reasons teachers rely on using the chalkboard (blackboard) is because there are too few textbooks for each student in the classroom. This forces teachers to duplicate handouts from the only textbook they possess.

### **Student-centred method**

Student-centred teaching is one of the most effective methods used in many classrooms by mathematics teachers. This method is increasingly favoured by teachers in PNG over the traditional, teacher-centred method described above. However, only four teachers interviewed for this study emphasised that they use student-centred methods such as group work, peer discussions, and presentations. These teachers give group work with specific instructions and organise students according to their ability levels to assist each other in learning while acting as a facilitator.

Teacher participant 6 focuses on group work in the classroom with a student within the group taking on leadership responsibilities, thereby allowing the students to take responsibility for their own learning and present their findings to the class. Besides these methods, this teacher also promotes students with different ability levels to work together in order for them to learn from each other. These two approaches allow the teacher to facilitate classroom learning while the students take control of their own learning. This teacher participant stated that:

This method is to give students group work and select someone to be the leader. After the explanations are done, the group leader takes care of the group. Later they do their presentation. Another method is they work in pairs instead of a big group. I select students who are fast workers, those who can work with supervisors, and I put them with someone who is very weak and slow. In that way, the person who can be able to understand more helps or assists, and I move around to assist in one way or another. (Group work and demonstration are the methods.) [Teacher 6]

A similar approach employed by teacher participant 6 is evident in the interview of teacher 3, who told of how the teacher-centred approach is strategised in the delivery of the lessons in their classroom. First, concepts are explained, and then group/peer work is given for students to check their own work and solve problems together. The teacher participant said:

First one is, ah, teacher-centred kind of lesson that the teacher talks and explains, ok. Teacher to students and another strategy is using groups, checking work in groups, ha, giving problems to each, allocating a problem to each groups and students work in groups. Working in pairs. Identifying students work in pairs solving problems together. [Teacher 3]

Furthermore, teacher 7 reported that to facilitate group work, they drill students for their speed and accuracy skills in a given time frame, and later further explain details of mathematics problems, as PNG students typically assume that mathematics is a difficult subject. This indicates that students' attitudes towards mathematics can have an effect on their mathematics learning. However, in their classroom, this teacher offers a detailed, clear explanation and facilitation of group work designed to assist students to overcome this challenge. As such, this teacher participant highlighted that:

Once they understand within the allocated [time], within, for instance, ten minutes, after that, I ask them to work in pairs or in groups in order for them to help each other. Sometimes maths is a difficult subject in PNG. There are many students who find it very hard to understand maths, so sometimes in my lesson, I try to break the example down into detail to explain for students to understand the concept of how to solve a particular problem. [Teacher 7]

Teacher participant 19 pointed out that their teaching method involves "mostly... demonstrations and explanations. Get students to work in pairs and as well as in groups" [Teacher 19]. For teacher 19, explanation and demonstration of ideas are employed first, followed by students being encouraged to work in pairs to explore and understand the concepts.

### **Using both teaching methods**

Three out of the 19 teachers interviewed use both teaching methods (teacher and student-centred methods) to deliver their mathematics lessons. Interestingly, two of the participants highlighted that:

First one is, ah, teacher-centred kind of lesson..., the teacher talks and explains, ok. Teacher to students, and another strategy is using groups, checking work in groups, ah, giving problems to each, allocating a problem to each group and students work in groups. Working in pairs. Identifying students work in pairs solving problems together. Ha. The other one is teacher-to-student. One-on-one assistance but not in class, outside of class. [Teacher 3]

I give a problem that may be on paper or on the board. It may be ten simple questions to do with multiplication, division, word problem, or a graph. I give back to them, and they must come up with an answer. Tell them to stop after ten minutes, and they have a group discussion for two minutes. Before, the slow kids had problems understanding, plenty of work for me, but I put them in groups for group talking, and someone has the answer to help the others. I work around to hear what they are doing to and assist them. [Teacher 18]

The two teachers above have used both methods in their teaching, with the traditional method employed in the first part of the lesson to explain ideas and procedures, while the student-centred approach is used in the second part to emphasise the importance of solving mathematics problems in groups for better understanding. It is interesting to note how they have planned their lessons in a similar format. These two teachers seem to understand the importance of both methods in the students’ learning process and have employed them meaningfully in their lessons. However, there are also challenges associated with employing these teaching methods effectively. Two participants said:

Most basically like our... current population, before it used to be 1:35 students, currently this 21st century, especially, we have like 1: 65 to 70 and so forth. The previous methods of... teaching, ah, some strategies that we used we have used in the past we don’t apply them at the present [Teacher 1].

Teaching methods are aids like handouts, and textbooks. We have limited textbooks as I’ve said earlier, and then access to the internet and so forth which is a major problem in our school. Most of the students and then the school, we don’t have internet access so... that is a major problem in our school... in order for us to teach them those lessons... that can really keep them up to the latest standards. [Teacher 2]

These participants indicated that the increase in class sizes and a lack of learning resources at schools have hindered and affected teaching methods in the classroom. It is evident in the interview analysis that learning resources promote effective mathematics learning, and consequently improve students’ mathematics results.

The next step in the analysis is to compare the three teaching methods used by the teachers described above in qualitative analysis through quantitative methods. This comparison is conducted by analysing the teachers who are using each of the respective methods. A simple statistical one-way analysis of variance (ANOVA) test was employed to predict which of the three teaching methods had an influence on the students’ mathematics results. This approach was employed to identify the influence each teaching method has on the Grade 12 students’ results. The procedure was employed to gauge a clear understanding of the methods that affect

mathematics results. The outcomes of this analysis are displayed in the three tables below with their descriptions.

Table 1: Descriptive statistics of maths results for the three different teaching methods.

Maths Results				95% Confidence				
Teaching Methods	N	Mean	SD	Std Error	Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Teacher Centred	209	494.91	6.12	0.42	494.77	495.74	458.79	514.85
Student Centred	47	500.06	7.75	1.13	497.79	502.33	484.75	519.62
Both Methods	47	500.94	5.48	0.82	499.27	502.60	491.61	515.45
Total	303	496.60	6.79	0.39	495.83	497.37	458.79	519.62

The descriptive statistics associated with the three teaching methods employed by teachers are reported in Table 1. It can be seen that the teacher-centred method is associated with results numerically below the mean level (M=494.91), and the student-centred method (M=500.06) and both methods (M=500.94). The total mean is 496.60, which is not too different from the mean of the teacher-centred method.

Table 2: ANOVA analysis result of the overall teaching method.

Maths Results					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1988.02	2	994.01	24.94	0.00
Within Groups	11836.11	297	39.85		

Table 2 shows the output of the ANOVA analysis, indicating whether there is a statistically significant difference between our group means. The results shown in Table 2 indicate that the significance value is 0.000 [F (2,994) = 24.94, p = .000], which is below 0.05 and, therefore, there is a statistically significant difference in the mean of the three teaching methods used to determine the students’ mathematics results.

Table 3: Post hoc tests for the each of the teaching methods for comparison.

Dependent Variable: Maths Results						
Tukey HSD		95% Confidence Interval				
(I) Teaching Methods	(J) Teaching Methods	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Teacher Centred	Student Centred	-5.15	1.02	0.00	-7.55	-2.75
	Both Centred	-6.02	1.04	0.00	-8.49	-3.56
	Teacher Centred	5.15	1.02	0.00	2.75	7.55
Student Centred	Both Centred	-0.87	1.32	0.78	-3.99	2.23
	Teacher Centred	6.02	1.04	0.00	3.56	8.49
Both Methods	Student Centred	0.87	1.32	0.78	-2.25	3.99

It is apparent from the results that there are statistically significant differences between the groups as a whole but the differences between the three teaching methods have not yet been shown. Therefore, the post hoc test of one-way ANOVA shown in Table 3 illustrates the multiple comparisons, showing how the teaching methods differed from each other. There is no significant ( $p > 0.05$ ) difference between the student-centred teaching method and mixing both teaching methods. However, it is also evident from the mean results from Table 1 and post hoc test results from Table 3 that the student-centred teaching method and mixing both teaching methods score significantly ( $p < 0.05$ ) higher than teacher-centred teaching methods. These results suggest that employing student-centred teaching methods and mixing both teaching methods makes a significant difference compared to using only the teacher-centred teaching method.

## Discussion on the teaching methods

As expected, *teaching method* is one of the main themes that emerged across the interviews. All participants reported that teaching methods have an impact on students' mathematics results; however, the findings from the interviews reveal that there is more impact for some participants than others due to the different teaching methods employed in the delivery of the mathematics lessons. Most of the participants employ traditional methods, with some participants using student-centred methods, and a few incorporating both methods.

It is important to note that teachers' actions and inactions may impact positively or negatively on students' learning experiences in mathematics (Ampadu, 2012; Yasmin et al., 2019; Schotgues, 2022). This is because students' learning experiences are to a large extent controlled by their teachers, and teachers tell students which questions to solve and which methods to use. Most of the participants in this study believe that students learn and perform better in mathematics when teachers are at the centre of the teaching process (i.e., the teacher-centred approach). This means that teachers explain concepts and take full control of the learning session (Yasmin et al., 2019). However, the results of the post hoc test in Table 3 reveal that the student-centred teaching method, and mixing both teaching methods, make a highly significant ( $p < 0.05$ ) difference on students' mathematics results, compared to teacher-centred methods. In other words, teachers employing student-centred methods and mixed-methods in teaching at secondary schools in Port Moresby are more likely to influence Grade 12 students' mathematics results than the teacher-centred teaching method. The teacher participants who employed student-centred methods stressed that these methods enable students to be more responsible for their own learning, with more group discussions to assist each other's learning. Studies have also argued that student-centred methods promote discovery learning to understand and learn new ideas, as well as encouraging students to work cooperatively with peers when tackling mathematics problems, and ultimately assisting them to obtain better results (Emre-Akdogan & Yazgan-Sag, 2019; Lahdenperä et al., 2019; Leong et al., 2019). This argument is supported by the ANOVA

test results in Table 3; that teachers using student-centred methods and both teaching methods are likely to influence students' mathematics results. The teachers surveyed who incorporate both teacher and student-centred teaching approaches use the former to explain step-by-step process on the blackboard, and the latter to actively engage students' in-group work (Oko, 2022). This approach is similar to that found in a case study by Ampadu (2012) in Ghana regarding students' perceptions of teachers. The combination of both teaching methods seems to assist students to understand mathematics ideas and concepts, and they are likely to perform better in mathematics.

These findings clearly indicate that student-centred teaching methods and both methods make a significant difference in the mathematics results of the students in Port Moresby. This result also supports the researcher's experience teaching in secondary schools in Papua New Guinea. However, the teachers interviewed who adopted these two methods did not go into detail about how they understood and developed their students' skills, in order to improve their teaching practices and better communicate mathematics concepts in the classroom.

## Conclusion

This study's findings from the interviews with nineteen Grade 12 teachers who participated in this study exhibited the primary theme that emerged from the results: teaching methods. Sub-categories within the main theme assisted in supporting and providing insight into the broader theme. The aim of this study was to capture information that might have been missed in teacher surveys to facilitate an in-depth exploration of the quality of teaching that affects students' mathematics results at the teacher-level.

It is clear from the findings of these interviews that the student-centred method and mixed methods have significant ( $p < 0.05$ ) effects, compared to the teacher-centred method. As the interview results have shown, the teaching methods adopted by teachers can assist and promote students' learning. However, as identified in the analysis, teachers also face challenges such as student population increases and a lack of learning resources in classrooms that may affect the practical delivery of lessons to effectively communicate content knowledge. On a positive note, some of the participants involved in this study acknowledged that they encourage students to have positive attitudes towards mathematics learning. They also suggested approaches to help students overcome their struggles with mathematics when the subject becomes difficult, assisting them to believe in their own mathematical abilities in order to obtain better results. These interview results support the literature review that teaching methods have a significant effect on students' mathematics results.

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