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Research Article

Effectiveness of questioning techniques in mathematics: An analysis of lecturers' practices at TVET colleges

Mbazima A. Ngoveni and Masilo F. Machaba

University of South Africa, South Africa

Correspondence should be addressed to Mbazima A. Ngoveni ngovema@unisa.ac.za
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This study evaluates the effectiveness of questioning techniques used by mathematics lecturers at Technical and Vocational Education and Training [TVET] colleges in South Africa. Employing a qualitative observational design, it examines how these techniques influence student engagement and learning outcomes, framed by Bloom's Taxonomy and Vygotsky's Social Constructivism. Observations of two lecturers reveal that while lower-order questions dominate, they result in limited student engagement and superficial learning. Higher-order questions, though less frequent, significantly enhance cognitive engagement and promote deeper understanding. The study suggests that a shift towards questions that stimulate analysis, evaluation, and creation can profoundly impact student interactions and learning. By integrating more dynamic and interactive questioning aligned with social constructivist principles, lecturers can foster an educational environment conducive to critical thinking and practical problem-solving, essential in TVET settings. This research contributes valuable insights into improving pedagogical practices through strategic questioning, advocating for continuous professional development to enrich teaching methodologies in line with modern educational demands.

Keywords: Bloom's taxonomy, cognitive processes, questioning techniques, social constructivism, student engagement

1. Introduction

Effective questioning is a critical educational strategy, particularly in mathematics education, where it serves to enhance student engagement and deepen understanding. Within the specialised context of Technical and Vocational Education and Training [TVET] colleges in South Africa, where the curriculum is designed to equip students with practical skills for specific vocations, the role of questioning becomes even more vital. Research, including studies by Tarasenkova et al. (2023), indicates a significant gap in the effective application and analysis of questioning techniques in these settings. This study aims to bridge this gap by examining the questioning strategies used by mathematics lecturers at TVET colleges and assessing their impact on student learning and engagement. The objective is to provide insights that could lead to enhanced pedagogical practices, tailored to meet both the educational and vocational needs of TVET students.

In educational settings, the importance of effective questioning has been robustly validated by research highlighting its role in promoting critical thinking and problem-solving skills. For example, Mahmud et al. (2021) noted that effective questioning strategies are crucial in active learning environments, encouraging students to think deeply and reflectively about mathematical concepts. The proper use of questioning can significantly shift student outcomes from mere fact recall to a comprehensive understanding of complex concepts through exploratory and higher-order questions. These strategies not only check for comprehension but also stimulate curiosity and promote a robust engagement with mathematical theories.

However, in South African TVET colleges, the implementation of effective questioning practices is often challenged by the need to prepare students for practical technically demanding environments. Traditional pedagogical methods, which often emphasize rote learning and passive student participation, are frequently inadequate for fostering the analytical skills required in modern workplaces (Vimbelo & Bayaga, 2023a). Additionally, the integration of indigenous knowledge and contextual relevance in teaching can enhance student understanding and engagement, as highlighted by Madimabe et al. (2022).

Further exploring the dimensions of effective teaching, the recent study by Mangwiro and Machaba (2023) underscores the transformative potential of dynamic and contextually relevant questioning in improving students' mathematical reasoning and problem-solving abilities. These techniques not only probe students' understanding but also challenge them to link mathematical theories to real-world applications. This paper focuses on assessing the effectiveness of questioning techniques employed by two mathematics lecturers at TVET colleges. By observing and analysing these techniques, the study will assess how they correlate with student performance and engagement, contributing to the improvement of teaching methodologies and educational outcomes in the TVET sector, and aligning with modern demands for a more interactive and practical learning environment.

Effective questioning techniques are pivotal in mathematics education, fostering student engagement and deepening their comprehension and mastery of complex concepts. This literature review synthesizes findings from recent studies, emphasizing their application within Technical and Vocational Education and Training colleges in South Africa, alongside broader educational settings.

Vimbelo and Bayaga (2023b) highlight the importance of a humanizing pedagogy in South African TVET colleges. Their study investigates the impact of making mathematics teaching more relatable to students' lived experiences. By integrating humanizing pedagogical approaches, they report enhanced student engagement and a deeper linkage between mathematical concepts and practical applications. This approach addresses the disengagement often seen in environments where traditional teaching methods predominate, which tends to isolate mathematics from its practical applications (Vimbelo & Bayaga, 2023a).

Further research by Vimbelo and Bayaga (2023b) reviews existing pedagogical practices within TVET mathematics education. Their findings indicate a predominant reliance on traditional, didactic teaching methods that may not effectively prepare students for real-world mathematical applications. They advocate for a diversified pedagogical approach, suggesting that incorporating varied teaching strategies, particularly dynamic and student-centred questioning techniques, could significantly enhance educational outcomes (Vimbelo & Bayaga, 2023b).

Sehole et al. (2023) focus on the conceptual misunderstandings that students encounter when learning about functions. Their research underscores the necessity for lecturers to employ diverse questioning strategies that cover all aspects of mathematical functions to improve understanding and reduce conceptual errors. This study highlights the role of effective questioning in diagnosing and addressing specific student misunderstandings, facilitating a more comprehensive grasp of mathematical concepts (Sehole et al., 2023).

The effectiveness of questioning in stimulating mathematical creativity is examined by Aziza (2021), who finds that open-ended questions particularly promote deeper thinking and creativity in mathematics. This aligns with the work of Othman et al. (2022), who investigate how questioning can support dialogic teaching. Their studies collectively demonstrate that effective questioning not only fosters a better understanding but also enhances the overall educational dialogue between teachers and students, crucial for developing critical thinking and problem-solving skills (Aziza, 2021; Othman et al., 2022).

The need for training in effective questioning is highlighted by Steyn and Adendorff (2020), who analyze the development of questioning skills among Foundation Phase Education students. Their findings advocate for enhanced training programs that specifically focus on the strategic use of questioning in teaching mathematical problem-solving. Similarly, Tarasenkova et al. (2023) emphasize the importance of aligning questions with didactic purposes to optimize teaching outcomes, suggesting that teacher education programs need to prioritize the development of these skills (Steyn & Adendorff, 2020; Tarasenkova et al., 2023).

Finally, the impact of oral questioning techniques is explored by Aziza (2021) and Mahmud et al. (2021). Their research shows that oral open-ended questions not only encourage diverse student responses but are also crucial in promoting deeper engagement and critical thinking. These studies highlight the importance of oral questioning in encouraging students to articulate their reasoning, thereby deepening their understanding and engagement with mathematical content (Aziza, 2021; Mahmud et al., 2021).

In conclusion, the reviewed literature underscores a consensus on the crucial role of effective questioning techniques in enhancing mathematics education, particularly within the diverse context of South African TVET colleges. By moving towards more humanized, engaging, and student-centred pedagogical approaches, educators can significantly improve the way students interact with and comprehend mathematical concepts. This review calls for ongoing research and development in questioning techniques to continually improve mathematics education in line with evolving educational needs and standards.

2. Background

This research utilises social constructivism and Bloom's taxonomy as its theoretical underpinnings. Essentially, integrating social constructivism with Bloom's Taxonomy offers a comprehensive and nuanced approach to examining and enhancing questioning methods in mathematics education. This framework enables teachers to design questions that both cognitively stimulate students and foster social interaction, thereby facilitating more profound learning and improved educational results.

2.1. Social Constructivism

Social constructivism, based on the theories of Vygotsky, posits that learning is fundamentally a social process. This perspective is crucial for understanding the dynamics of classroom interactions, especially the use of questioning techniques. Vygotsky’s notion of the Zone of Proximal Development [ZPD] underscores the importance of interactions that occur within the learner’s capabilities when supported by a more knowledgeable individual, such as a teacher (Vygotsky & Cole, 1978). In the context of mathematics education, questions designed by the teacher can serve as the scaffolding that assists students in moving from current knowledge to a deeper, more comprehensive understanding. This aligns with Palincsar's (1998) discussion on the social constructivist perspectives on teaching and learning, which highlights how social interactions through questioning can facilitate cognitive development.

2.2. Bloom's Taxonomy

Bloom's Taxonomy, originally developed by Bloom et al. (1956) and later revised by Anderson and Krathwohl (2001), categorizes educational goals into a hierarchy from simple to complex. This taxonomy is instrumental in structuring questioning techniques that engage students at different cognitive levels. For example, lower-order questions (remembering and understanding) can be used to assess students’ basic knowledge and comprehension, while higher-order questions (applying, analysing, evaluating, and creating) encourage deeper engagement and critical thinking (Anderson & Krathwohl, 2001). Effective questioning, as structured by Bloom’s taxonomy, can lead students through a cognitive journey from the basic recall of facts to the ability to analyse and synthesize information, thus fostering a robust learning environment.

2.3. Integrating the Frameworks

Integrating social constructivism with Bloom's Taxonomy offers a comprehensive approach to understanding and improving questioning techniques in mathematics education. Social constructivism focuses on the social aspects of learning and emphasizes the role of interaction, which is vital for the effective use of questioning. Questions crafted in line with Bloom’s taxonomy can ensure that these interactions are cognitively engaging and appropriate to the students' learning stages. King (1994) illustrates this integration effectively, demonstrating how questions can guide knowledge construction in the classroom, enhancing both the teacher-student and student-student dialogues, thus facilitating the co-construction of knowledge.

In practice, when teachers design their questioning strategies, they can apply social constructivist principles to create a supportive learning environment. Simultaneously, by employing Bloom's taxonomy, they can structure these questions to progressively challenge students, fostering deeper understanding and critical thinking. This approach not only adheres to theoretical models but also aligns with empirical research that supports the effectiveness of well-structured questioning in promoting significant learning outcomes.

3. Method

This research employs a qualitative observational design to investigate the questioning techniques used by mathematics lecturers at Technical and Vocational Education and Training colleges. The decision to use direct observations stems from the need to capture real-time, authentic interactions between lecturers and students in their natural classroom settings, providing a depth of context and immediacy that other data collection methods cannot (Kawulich, 2005).

3.1. Data Collection Procedure

The data collection in this study consisted mainly of observations and field notes.

3.1.1. Observations

Observations were conducted during regular class sessions, with the researcher acting as a non-participative observer to minimize the impact on the classroom dynamics. A structured observation guide was used, focusing on:

- Types of Questions: Documenting the variety and complexity of questions posed by lecturers.
- Student Responses: Observing the immediacy and nature of student responses.
- Engagement Levels: Noting overall student engagement and interaction patterns within the classroom.

3.1.2. Field notes

Detailed field notes were taken during each observation session. These notes included both descriptive data about the lecturers' questioning techniques and reflective observations about the engagement and interaction dynamics (Emerson et al., 2011). The field notes were instrumental during the data analysis in this study as they included the sequence at which events occurred and any points that could easily be forgotten in the their absence.

3.2. Data Analysis

Thematic analysis was employed to analyse the observational data, allowing for the identification and interpretation of themes related to effective questioning techniques and their impact on student learning. This analysis method is appropriate for studies where data are rich in detail and contextual complexity as was the case in the primary study (Braun & Clarke, 2006). In this study, the thematic analysis involves identifying and analyzing patterns within the data to understand the effectiveness of questioning techniques used by NC(V) mathematics lecturers at TVET colleges. The themes emerge from the classroom observations and detailed field notes, while being grounded in theoretical frameworks such as Bloom's Taxonomy and Vygotsky's Social Constructivism. In no particular order, the themes that emerged from this study were:

- Cognitive Challenge
- Student Engagement
- Pedagogical Strategies

- Questioning Technique

3.3. Triangulation of Data

To ensure the reliability and validity of the findings, data triangulation was implemented by observing two lecturers across different classes and times until I decided on the lesson that I could record for the study. This approach helps to verify that the observed effects are consistent across different teaching styles and classroom environments (Denzin, 2017).

3.4. Ethical Considerations

This study is part of the main study in which ethical approval (Ref: 2021/04/14/36923567/32/AM) was obtained from the educational institution, and all observed parties were informed about the study's purpose and scope. Observations were conducted in such a way as to ensure minimal disruption to the natural learning environment. Confidentiality and anonymity of all participants were maintained throughout the study.

4. Findings

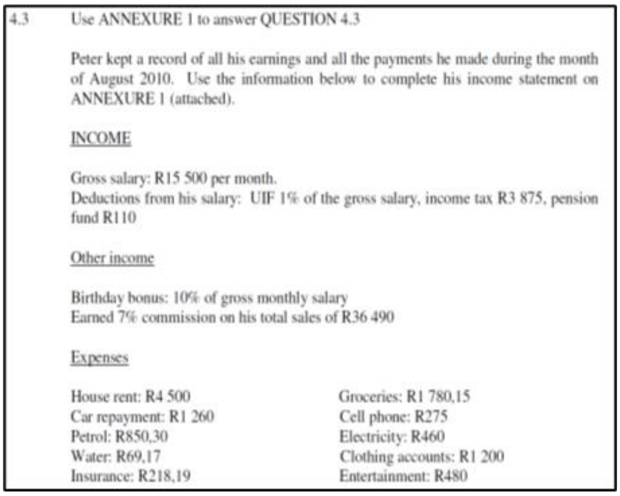
Below we present how we discuss the findings from the observations from the two lecturers.

4.1. Lecturer X Observations

Lecturer X distributed the income and expenditure extracted from one of the previous question papers to all students in class; refer to Figure 1. He asked students to complete the income and expenditure sheet provided. This was his first engagement with the content after introducing the lesson objectives. This was followed by doing corrections after students had completed the activity.

Figure 1

Income and Expenditure Activity



4.3 Use ANNEXURE 1 to answer QUESTION 4.3

Peter kept a record of all his earnings and all the payments he made during the month of August 2010. Use the information below to complete his income statement on ANNEXURE 1 (attached).

INCOME

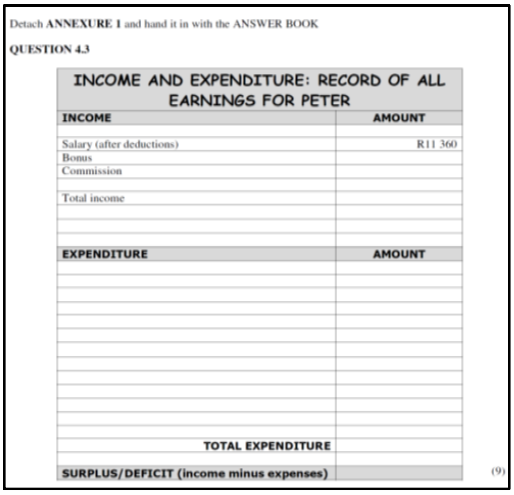
Gross salary: R15 500 per month.
Deductions from his salary: UIF 1% of the gross salary, income tax R3 875, pension fund R110

Other income

Birthday bonus: 10% of gross monthly salary
Earned 7% commission on his total sales of R36 490

Expenses

House rent: R4 500	Groceries: R1 780,15
Car repayment: R1 260	Cell phone: R275
Petrol: R850,30	Electricity: R460
Water: R69,17	Clothing accounts: R1 200
Insurance: R218,19	Entertainment: R480



Detach **ANNEXURE 1** and hand it in with the ANSWER BOOK

QUESTION 4.3

INCOME AND EXPENDITURE: RECORD OF ALL EARNINGS FOR PETER	
INCOME	**AMOUNT**
Salary (after deductions)	R11 360
Bonus	
Commission	
Total income	
EXPENDITURE	**AMOUNT**
TOTAL EXPENDITURE	
SURPLUS/DEFICIT (income minus expenses)	

(9)

4.1.1. Corrections for Classwork (Activity 1)

I discuss how the lecturer worked with the students to make corrections to the given classwork (refer to Figure 1). The student, in this case, refers to any student present in the classroom. The corrections refer to the income and expenditure that students had to complete.

Lecturer X: I hope that we are all finished. Let us make corrections. What is the bonus here, class?
Student: R1550.
Lecturer X: Is it correct, class?
Class: Yes.
Lecturer X: Good [while comparing with his answer]. What is the commission?

After completing the corrections, the lecturer moved on to the next section, as shown below. He treated two examples with students and below is one of them.

4.1.2. First example treated in the classroom

Question: A salary of R17200 per month is increased by 4,5%.

Lecturer X: Given the question in 2.1, what are we expected to do, class?
Student: Sir, I think they want us to add 4.5% of R17 200 to R17 200 to get the answer.
Lecturer X: Good. In order to increase an amount by a percentage, we should add that amount and the same amount multiplied by the percentage increase. Other calculators can do this operation, and if you can manage it, you may not worry much about showing the steps. For the purpose of this lesson, we are going to show these steps.

$$17200 + \frac{4.5}{100} \times 17\,200 = R17\,974$$

Let us move on to a case where we have a decrease.

4.1.3. Second example treated in the classroom

An insurance premium of R250 per month is decreased by 1.5%. The same procedure as the one in example one was followed. Lack of whole class engagement was observed. It is worth noting that throughout the lesson, few students actively participated in the lesson by providing answers.

4.1.4. Analysis: Questioning technique

Lecturer X utilized a direct questioning technique, where he asked specific, factual questions related to the students' completed classwork. The questions primarily focused on finding the correct answers rather than exploring the underlying mathematical concepts or processes. For example, questions like "What is the bonus here, class?" and "What is the commission?" are aimed solely at eliciting specific numerical responses from the students.

4.1.5. Cognitive level

The cognitive level addressed in Lecturer X's class predominantly focuses on the lower tiers of Bloom's Taxonomy, specifically the "remembering" and "understanding" categories. The interactions during the session, such as asking students to recall specific figures and verify correctness, cater primarily to basic recall and comprehension skills. This approach does not facilitate engagement in higher-order thinking processes, such as analysis or evaluation, which are crucial for deeper learning and the development of critical thinking skills.

4.1.6. Engagement and interaction

The engagement and interaction pattern observed in Lecturer X's classroom is predominantly one-directional, characterized by the lecturer posing questions and students responding. This method results in minimal follow-up or probing that might encourage deeper student engagement or interaction. Such a dynamic can significantly limit the opportunities for students to explore mathematical concepts more deeply or to develop critical thinking skills. Without more interactive or exploratory dialogue, students are less likely to challenge their understandings or to engage in the critical analysis of content, which are essential components of higher-level learning.

4.1.7. Pedagogical strategies

Lecturer X uses direct instruction and corrective feedback during the class, which are common in traditional teaching methods. The approach is straightforward. Lecturer X begins the session by distributing income and expenditure sheets, setting a clear and task-oriented start to the class. This distribution of materials provides a structured approach, allowing students to immediately engage with the content. However, during interactive corrections, where the lecturer asks students about specific entries like bonus, commission, and total income and confirms their answers, the interaction remains superficial. This method engages students but does not promote deeper interaction or critical thinking about the material.

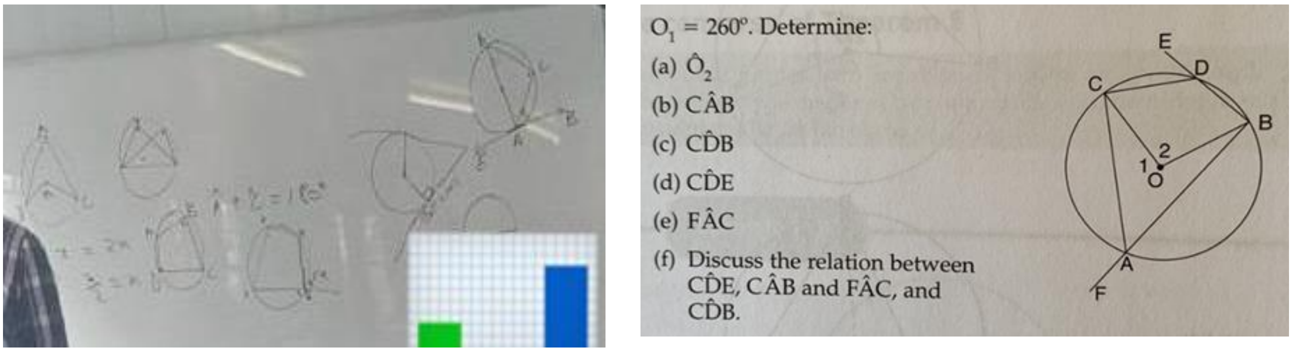
In example solving, the lecturer demonstrates percentage increases and decreases through explicit calculations, providing concrete examples that effectively cater to visual and practical learners. This approach includes one example involving a percentage increase and another around a percentage decrease, offering direct application of concepts. Despite these strengths, the session misses opportunities for higher-order thinking. Lecturer X could significantly enhance cognitive demand by incorporating scenarios that require students to make financial decisions based on their calculations or to predict the effects of various financial decisions. Additionally, the class participation was limited; the lecturer struggled to involve the entire class, resulting in only a fraction of students being actively engaged during the lesson. This limited participation suggests a need for more inclusive and interactive teaching strategies to ensure broader engagement.

4.2. Lecturer Y Observations

Lecturer Y introduced the topic: Prove and apply the theorem: The angle between a tangent to a circle and a chord drawn from the point of contact is equal to an angle in the alternate segment (tan-chord theorem). This is what he was supposed to treat on the day, but he ended up revising the theorems that he did previously. Figure 1 below visually illustrates the theorems that were summarised by the lecturer. Meaning, that he did not arrive at the intended theorem.

Figure 2

Lecturer Y Summary of Theorems and Example Treated in Class



Lecturer Y: Given the circle with the rectangle ABCD in Figure 1, with A, B, C, and D touching the circle as we see, what can we remember from what we have learnt?

Student: $\hat{A} + \hat{C} = 180°$

Lecturer Y: Thank you [while writing the answer down.] What is your reason?

Student: Opp ∠s of cyclic quad.

Lecturer Y: Thank you so much. [He then proceeded to the next theorem and did the same.]

He revised the rest of the theorems as they appeared on the whiteboard (Figure 1) and treated two problems with the students. Below I discuss how the lecturer worked out the problem.

Lecturer Y: Let us use the knowledge that we have just revised to answer this question in our textbooks. Who can find the answer for $\hat{0}2$ for us? Can a volunteer come and calculate $\hat{0}2$ on the board for us?

Student: $\hat{0}_1 + \hat{0}_2 = 360°$ (∠s round a pt)

But, $\hat{0}_1 = 260°$

$\therefore \hat{0}_2 = 360° - 260° = 100°$

Lecturer Y: Is everything correct here?

Class: Yes

Lecturer Y: Who can find answer for $C\hat{A}B$ for us?

Student: $\hat{0}_2 = 2 \times C\hat{A}B$ (*∠ at centre = 2 ×∠ at circumference)*

$100° = 2 \times C\hat{A}B$

$\therefore C\hat{A}B = 50°$

Lecturer Y: Is everything correct here?

Class: Yes
Lecturer Y: Thank you. Next question, who is doing it for us?
Student: $\hat{0}_1 = 2 \times C\hat{D}B$
$260° = 2 \times C\hat{D}B$
$\therefore C\hat{D}B = 130°$

The routine continued for the remainder of the questions. The last question was slightly different to the rest of the questions as it appears below.

Lecturer Y: Class, in this question, we must discuss the relationship between $C\hat{D}E, C\hat{A}B, \text{and then } F\hat{A}C, C\hat{D}B$. Any volunteer on this one?
Student: I think the two pairs are equal because $C\hat{D}E = C\hat{A}B = 50° \text{ and } F\hat{A}C = C\hat{D}B = 130°$ as we calculated here sir.
Lecturer Y: What do you think, class?
Class: It is correct sir.
Lecturer Y: I agree with you guys. We were supposed to do the next theorem today, but because of time, we will do it tomorrow.

In the last question, the conclusion was supposed to address the deduction that "because two pairs of angles are equal", it means an "exterior angle of a cyclic quadrilateral is equal to the interior opposite angle", which is one of the theorems.

As was the case with Lecturer X, few students actively participated in the lesson by providing answers.

4.2.1. Analysis: Questioning technique

Lecturer Y's questioning technique primarily revolves around a traditional, direct approach where students are asked to recall and apply specific theorems to problems presented in class. This method effectively reinforces existing knowledge but lacks in facilitating deeper inquiry or exploration of new concepts. The questions posed often lead to straightforward answers that do not challenge students to engage in critical thinking or higher-order cognitive skills such as synthesis and evaluation.

Moreover, while the questioning does stimulate some student interaction, it is largely limited to recall and application, with little emphasis on encouraging students to analyze deeper connections or implications of the mathematical principles they are studying. The technique is efficient for reviewing and confirming knowledge but falls short in promoting a more interactive and explorative learning environment that could enhance students' understanding and engagement with the material on a deeper level.

4.2.2. Pedagogical strategies

Lecturer Y employs a traditional lecture-based approach, focusing primarily on reinforcing previously learned theorems rather than introducing new content as planned. Significant class time is spent reviewing theorems that have already been covered, which reinforces student understanding but fails to progress to the new theorem (tan-chord theorem) that was initially intended to be introduced. Additionally, during class, the lecturer guides students through solving geometric problems that apply these theorems, which aids in cementing their understanding through practical application. However, this approach, while beneficial for reinforcing existing knowledge, limits opportunities for introducing more advanced concepts and engaging students in higher-level cognitive activities.

4.2.3. Student engagement

The interaction between Lecturer Y and the students suggests a moderate level of engagement. The active participation seen in the classroom, characterized by students solving problems and responding to questions, indicates engagement but primarily within a limited scope focused on recall and application. This type of participation suggests that while students are responsive, the learning activities might not adequately challenge them to explore beyond the basic application of concepts. Moreover, the prevalent question and answer (Q&A) method, although effective for concept review, falls short in fostering deeper insights or stimulating critical thinking that extends beyond the immediate context of problem-solving. Additionally, while the questions posed have the potential to encourage group work and collaboration, there is a missed opportunity to fully utilize discussions and collaborative tasks to deepen understanding and engage students in more meaningful interactions that promote higher-order cognitive skills.

4.2.4. Cognitive challenge

The cognitive challenge presented in the session is relatively focused on application and analysis. Students are regularly applying known theorems to new problems, which serves as a beneficial exercise for enhancing understanding and retention. This approach solidifies foundational knowledge but could be expanded to integrate applications that challenge students to think beyond the conventional scopes.

While students are encouraged to analyze relationships between different geometric elements, the scope for engaging in higher-order cognitive processes such as synthesis and evaluation remains limited. This limitation often arises from the repetitive nature of tasks and a lack of progression to more complex or innovative material. To fully develop students' analytical capabilities, the tasks need to be diversified and deepened to include more challenging and novel scenarios.

5. Discussion

5.1. Questioning Techniques of Lecturers X and Y

Lecturer Y's questioning technique, mirrors that of Lecturer X, revolve around a traditional, direct approach focused on the recall and application of specific theorems to problems presented in class. This method effectively reinforces existing knowledge but is limited in promoting deeper inquiry or the exploration of new concepts. Both lecturers primarily engage students in the lower cognitive levels of Bloom’s taxonomy—remembering and understanding—as previously discussed. Anderson and Krathwohl (2001) emphasize that such questions fail to sufficiently challenge students to engage in higher-order cognitive processes like analysis and evaluation, which are crucial for more profound educational development.

Additionally, while some student interaction is stimulated, it predominantly revolves around factual recall and application, with little encouragement for students to delve into deeper connections or implications of mathematical principles. This approach aligns with the observations by Aziza (2021) and Othman et al. (2022), who note that open-ended questions can stimulate diverse responses and deeper thinking, thereby enhancing creativity and understanding among students. Both Lecturer X and Y’s techniques, while efficient for reviewing and confirming knowledge, fall short of promoting a more interactive and explorative learning environment that could enhance students' understanding and engagement on a deeper level. By integrating findings from these studies, it's clear that both lecturers would benefit from structured training to develop more effective questioning. Similarly, the findings of Steyn and Adendorff (2020), posit that there is a clear need for structured training to develop more effective questioning skills in foundational mathematics education, fostering an environment conducive to critical thinking and effective learning.

5.2. Social Constructivism and Engagement

Lecturer Y's traditional lecture-based approach, similar to Lecturer X's, primarily involves recalling and applying previously learned theorems, which starkly contrasts with the principles of social constructivism. As defined by Vygotsky and Cole (1978), effective learning within this framework should be fundamentally collaborative and interactive, involving knowledge construction through social interactions and shared experiences. However, both lecturers' use of one-directional questioning strategies fails to incorporate the necessary interactive and collaborative elements, limiting the depth and engagement of student learning.

To align more closely with social constructivist principles, it is recommended that both lecturers integrate more collaborative activities, such as structured group discussions, peer-assessment techniques, and interactive problem-solving sessions. This shift would transform the classroom into a dynamic environment where students actively participate in constructing knowledge, enhancing engagement and deepening their understanding. Steyn and Adendorff (2020) support the development of questioning skills that promote higher-order thinking, while Palincsar (1998) advocates for scaffolded instruction that challenges students just beyond their current abilities. These strategies would not only enhance teaching effectiveness but also ensure that the educational experience is richly aligned with social constructivist ideals.

5.3. Implications for Pedagogical Strategies and Cognitive Challenge and Bloom's Taxonomy

Lecturers X and Y both employ traditional teaching approaches that emphasize direct questioning strategies, largely focusing on recall and application of previously learned theorems. Lecturer X's reliance on such methods primarily elicits specific, often factual responses, which while effective for reviewing concepts, does not encourage deeper cognitive engagement or promote critical thinking. Aziza (2021) and Othman et al. (2022) suggest that incorporating open-ended questions could foster more diverse responses and stimulate deeper thinking, thereby enhancing creativity and understanding among students.

Lecturer Y's approach also involves a consistent review of previously learned theorems without introducing more challenging content that could engage higher cognitive functions as outlined in Bloom's taxonomy. This method helps in reinforcing basic understanding but falls short in advancing students' cognitive development towards higher-order thinking skills, such as analysis and evaluation, which are crucial for effective problem-solving. Köksal et al. (2023) highlight the need for educational strategies that push beyond mere recall and application, a sentiment echoed by Mangwiro and Machaba (2023), who criticize the lack of progression to new and more complex material that could enhance students' problem-solving abilities. These criticisms point to a necessary shift in pedagogical strategies for both lecturers towards more dynamic and interactive learning experiences that better align with social constructivist principles and promote deeper cognitive engagement.

5.4. Student Engagement and Questioning Strategy

The moderate student engagement observed with Lecturer Y aligns with findings by Steyn and Adendorff (2020), where traditional didactic methods often result in limited active participation. This method is less conducive to stimulating interactions advocated by Vygotsky and Cole (1978) and Palincsar (1998), which can significantly enhance learning through guided dialogue and collaborative problem-solving.

5.5. Analysing the Impact of Current Questioning Techniques

Analysing the current questioning strategies of Lecturers X and Y highlights a fundamental issue in fostering higher-order thinking. Lecturer X's questioning primarily focuses on eliciting factual responses, and reinforcing mathematical processes, but limiting the potential for students to deeply analyse or synthesize information. This aligns with the concerns raised by Anderson and Krathwohl (2001) about how lower-order questioning fails to encourage critical engagement. The unidirectional flow of questions from Lecturer X leaves students with limited opportunities to reflect on or connect mathematical concepts to broader applications. Similarly, Lecturer Y's reliance on reiterating previously learned concepts without progressing to new, more complex material demonstrates a missed opportunity for advancing students' cognitive development. This strategy might ensure basic comprehension, but it does little to challenge students to explore mathematical concepts beyond surface-level understanding.

5.6. Strategies for Enhanced Pedagogical Effectiveness

To address these shortcomings, both lecturers should consider adopting diverse questioning techniques that better align with the social constructivist principles outlined by Vygotsky and Cole (1978). For Lecturer X, this means shifting from a solely factual approach to one that encourages students to hypothesize and analyse mathematical scenarios, fostering an environment where knowledge is collaboratively constructed. Lecturer Y can enhance his methods by integrating higher-order questions that encourage evaluation and synthesis, thus pushing students to engage with mathematical concepts in more complex ways. Collaborative problem-solving, as Gudaji (2019) suggests, should be more deeply integrated into both lecturers' methodologies to encourage group-based engagement and enhance peer learning. The recommendations align with the importance of continuous professional development, where both lecturers can learn to craft questions that span the full spectrum of Bloom’s taxonomy, promoting an environment conducive to critical thinking and effective learning.

6. Conclusion

In conclusion, this study's examination of Lecturers X and Y, covering both practical and theoretical mathematical contexts, highlights the limitations of relying primarily on direct, low-level questioning. In practical applications of income and expenditure (Lecturer X) and theoretical geometric theorems (Lecturer Y), the focus on basic recall and understanding fails to adequately develop students' analytical or evaluative skills. To address these shortcomings, incorporating open-ended questions and interactive, collaborative strategies into teaching practices is essential. These improvements would not only promote deeper cognitive engagement but also align their methods with social constructivist principles, fostering an educational environment that encourages critical thinking and creative problem-solving. This approach is supported by scholars such as Aziza (2021) and Othman et al. (2022), who advocate for educational practices that enhance creativity and understanding among students, preparing them for advanced academic challenges and real-world problem-solving.

It is advisable for lecturers to incorporate a broader range of questioning techniques to facilitate deeper cognitive engagement. According to Anderson and Krathwohl (2001), effective questions should span various cognitive levels within Bloom's taxonomy, from basic recall to synthesis and evaluation. Emphasizing collaborative learning, aligned with socio-constructivist principles as Gudaji (2019) suggests, would enhance understanding through peer interaction. Lecturers could incorporate more group-based problem-solving sessions to engage students with mathematical concepts more dynamically.

Aligning questions with didactic purposes to enhance educational outcomes is crucial, as discussed by Tarasenkova et al. (2023). Continuous professional development in questioning strategies would equip lecturers with the necessary skills to design questions that cover the full range of Bloom’s taxonomy and promote collaborative learning.

7. Recommendations

Based on the results of the study, some suggestions were made for future research. In this context, little is known about the relationship between questioning techniques and student learning outcomes in mathematics. Future research could address this. This could include collecting data on student performance, attitudes and perceptions of mathematics before and after the implementation of the questioning techniques intervention. Another recommendation is to examine the impact of questioning techniques on student motivation and engagement in mathematics. This could involve collecting data on student attitudes, self-efficacy and interest in mathematics before and after the implementation of questioning techniques. Finally, with the increasing use of technology in education, future studies could investigate how digital tools can support questioning techniques in mathematics education. This could involve exploring the potential benefits and limitations of using digital tools to facilitate questioning and feedback.

8. Limitations of the Study

The paper has some limitations that should be considered. First, the study focuses only on two lecturers, which limits the ability to generalize findings across a broader educational context. The teaching styles and strategies observed may not represent a wider range of teaching practices in different subjects or institutions. Second, the conclusions drawn are largely based on observations of teaching practices without quantitative data to support findings. This reliance on qualitative analysis may introduce observer bias and reduce the objectivity of the results.

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