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The Impact of Conducive Learning Environments on Learners' Attitudes Towards Geometry: A Null Relationship

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ABSTRACT

Geometry remains a critical component of mathematics education due to its role in developing spatial reasoning, logical thinking, and problem-solving skills essential for STEM-related fields. However, persistent negative learner attitudes toward geometry continue to hinder achievement and engagement, particularly in under-resourced educational contexts. While existing literature suggests that conducive learning environments positively influence learner attitudes, limited research has explored this relationship specifically within geometry or examined contexts where such relationships may be inconsistent or complex. Therefore, this study investigated the relationship between conducive learning environments and learners' attitudes toward geometry. Guided by the Community of Inquiry (CoI) framework, the study adopted a mixed-methods approach. Quantitative data were collected through questionnaires and analysed using chi-square tests and contingency coefficients to determine the strength of association between variables. Qualitative data were obtained through semi-structured interviews with mathematics teachers and analysed thematically, with findings interpreted through the lenses of teaching, cognitive, and social presence. The quantitative results revealed a statistically significant and moderately strong relationship between learning environments and learners' attitudes toward geometry ($\chi^2 = 53.146$, $p < 0.001$; $V = 0.543$). However, qualitative findings indicated that systemic challenges, such as overcrowded classrooms, limited resources, inconsistent pedagogical practices, and weak learner engagement, constrain the effectiveness of these environments. This study contributes to the literature by providing a context-sensitive understanding of the environment–attitude relationship, demonstrating that the alignment of instructional, cognitive, and social factors mediates the impact of conducive learning environments. It further highlights the need for integrated and sustainable interventions to improve geometry learning outcomes.

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1. INTRODUCTION

Geometry remains a critical domain in mathematics education due to its central role in developing spatial reasoning, logical thinking, and problem-solving skills essential for real-life applications such as engineering, architecture, and technological innovation [1; 2]. It enables learners to interpret and interact with the physical world, thereby strengthening their capacity to engage in STEM-related fields and everyday problem-solving [3; 4]. Furthermore, geometry supports the development of deductive reasoning and analytical thinking, which are fundamental for informed decision-making in both academic and real-world contexts [5]. Despite its significance, international assessments continue to highlight persistent underperformance in geometry, emphasizing its urgency as an area requiring focused educational attention [6].

However, learners face substantial challenges in mastering geometric concepts. Research indicates that many learners struggle with the abstract nature of geometry, particularly in understanding formal definitions, theorems, and proofs [1; 7]. Difficulties in interpreting geometric language and visualising spatial relationships further hinder conceptual understanding and problem-solving [5; 3]. Additionally, learners often rely on memorization rather than conceptual reasoning, which limits their ability to transfer knowledge to unfamiliar problems [8]. These cognitive challenges are compounded by affective factors such as low motivation, mathematics anxiety, and negative prior experiences, which contribute to disengagement and poor performance [9; 10].

Moreover, instructional and contextual factors continue to exacerbate these difficulties. Traditional teacher-centred approaches, limited use of visual and technological tools, and inadequate teaching resources restrict opportunities for active engagement and meaningful learning in geometry [11; 4]. Large class sizes and insufficient teacher support further reduce the effectiveness of instruction, particularly in under-resourced contexts [12]. These findings suggest that challenges in geometry learning are not solely cognitive but are deeply influenced by the quality of the learning environment and broader socio-educational conditions [13].

A conducive learning environment refers to a supportive and well-structured context that enables effective cognitive, social, and emotional engagement in learning. It is conceptualised as a multidimensional construct involving aligned elements such as clear instructional practices, positive teacher–learner relationships, psychological safety, and opportunities for active participation [14; 15]. In mathematics education, particularly geometry, such environments promote reasoning, interaction, and conceptual understanding while fostering positive learner attitudes [16; 17]. Conduciveness is also context-dependent, operationalised through interrelated dimensions such as teacher support, classroom management, and cognitive activation, which collectively shape learners' engagement and learning outcomes [18; 19].

Learner attitudes toward mathematics, including geometry, are conceptualised as a multidimensional affective construct comprising cognitive (e.g., beliefs and self-concept), affective (e.g., enjoyment or anxiety), and value-related (e.g., perceived usefulness) components [20; 19]. These dimensions interact dynamically and are shaped through

learning experiences, influencing motivation, engagement, and achievement in mathematics [17; 18].

Collectively, these constructs are reciprocally related: learning environments structure the conditions under which attitudinal dimensions develop, while learner attitudes mediate how learners perceive and respond to instructional contexts [16; 19].

Research shows that learners' attitudes toward geometry are inextricably shaped by the quality and nature of the learning environment, with significant implications for engagement, conceptual understanding, and achievement [16]. Constructivist and concept-oriented learning environments, characterised by collaboration, inquiry-based tasks and meaningful problem-solving, have been shown to foster deeper understanding and more positive learner attitudes compared to traditional, teacher-centred approaches [21].

In the context of geometry, the integration of dynamic visualisation tools and interactive pedagogies enhances learners' spatial reasoning, confidence, and interest, thereby promoting favourable dispositions toward the subject [17; 18]. Furthermore, recent empirical studies indicate that learner attitudes function as both outcomes and mediators of learning, influencing persistence, engagement, and success in geometric problem-solving [19]. Importantly, disparities in learning environments, such as limited access to resources or ineffective instructional practices, continue to negatively affect learners' attitudes and overall learning experiences, particularly in under-resourced contexts [14]. Collectively, these findings underscore that well-structured, learner-centred learning environments are essential for cultivating positive attitudes toward geometry, which in turn support higher-order thinking and sustained mathematical achievement.

Despite extensive research demonstrating that learning environments influence learners' attitudes toward mathematics, much of the existing literature treats both constructs in broad or generalised terms, often focusing on mathematics rather than domain-specific areas such as geometry [12; 8]. Geometry, however, presents unique cognitive and representational demands, such as spatial reasoning, visualisation, and proof, that may shape learners' attitudes differently from other mathematical domains [1]. However, there remains a limited body of empirical studies that specifically examine how conducive learning environments relate to attitudes toward geometry as a distinct construct.

Furthermore, prior studies have largely reported positive associations between supportive learning environments and favourable learner attitudes, often assuming a linear and direct relationship [11; 10]. This creates a critical gap in the literature: the possibility of a null or non-significant relationship is rarely explored or theoretically explained. As a result, there is insufficient understanding of the conditions under which learning environments may not significantly influence learners' attitudes, particularly in contexts where other factors are more influential. For example, prior knowledge, cultural perceptions of geometry, or assessment practices may play a more dominant role.

In addition, many existing studies lack precise operational definitions of "conducive learning environments," leading to inconsistencies in measurement and interpretation across contexts [4]. There is also a methodological gap, as much of the research relies on cross-sectional designs without adequately capturing the nuanced and context-dependent nature of classroom environments and learner attitudes over time.

Therefore, this study addresses three key gaps: (i) the limited focus on geometry-specific attitudes rather than general mathematics attitudes; (ii) the lack of research examining null or non-significant relationships between learning environments and attitudes; and (iii) the need for clearer conceptualisation and contextualisation of conducive learning environments within specific educational settings. By addressing these gaps, the study contributes to a more nuanced understanding of when and how learning environments influence learners' attitudes toward geometry, including circumstances where such influence may be minimal or absent.

This study therefore examines whether a statistically significant relationship exists between conducive learning environments and learners' attitudes toward geometry. By applying [22]'s Community of Inquiry (CoI) theoretical framework, the study provides a structured understanding of how environmental dimensions influence learner dispositions.

2. PROBLEM STATEMENT

Ideally, mathematics classrooms, particularly in geometry, should provide supportive, learner-centred learning environments that foster positive attitudes, engagement, and conceptual understanding, as emphasized in contemporary frameworks of effective pedagogy and global education benchmarks [12; 4]. Such environments are expected to nurture learners' affective, cognitive, and behavioural dispositions toward mathematics, thereby improving both participation and achievement [8]. However, the reality remains that many learners continue to experience geometry as abstract, difficult, and disconnected from meaningful learning, often resulting in negative attitudes, low motivation, and persistent underachievement, as evidenced in recent international and regional studies [6; 1]. While prior research has generally established a positive relationship between conducive learning environments and learner attitudes, these three gaps remain unaddressed: (i) the limited focus on geometry-specific attitudes rather than general mathematics attitudes; (ii) the lack of research examining null or non-significant relationships between learning environments and attitudes; and (iii) the need for clearer conceptualisation and contextualisation of conducive learning environments within specific educational settings. These gaps constrain a nuanced understanding of how and when learning environments influence attitudes, particularly in diverse educational settings. Addressing these disconnections is significant because learners' attitudes toward mathematics are strong predictors of engagement, persistence, and long-term participation in STEM pathways [10]. Moreover, improving learning environments aligns with United Nations Sustainable Development Goal 4 (Quality Education), which advocates for inclusive and effective learning environments that promote equitable educational outcomes. Therefore, the aim of this study is to examine the relationship between conducive learning environments and learners' attitudes toward geometry, with particular attention to the possibility of a null relationship, to contribute a more context-sensitive and theoretically grounded understanding of this association.

Main aim

To investigate the relationship between conducive learning environments and learners' attitudes toward geometry, with particular emphasis on determining whether such a relationship is significant or null within the study context.

Research Objectives

- To explore the characteristics of a conducive learning environment in the context of geometry education.
- To examine the potential relationship between the conduciveness of the learning environment and learners' attitudes toward geometry.
- To identify any factors that mediate or influence the relationship between the learning environment and attitudes toward geometry.

The study was guided by the hypothesis tested at a 0.05 significance level.

H_0: There is no significant relationship between a conducive learning environment and learners' attitudes towards geometry.

Research Question

Is there a relationship between a conducive learning environment and learners' attitudes toward geometry?

3. LITERATURE REVIEW

3.1 Teacher support and pedagogical practices

Recent studies have shown that teacher support and pedagogical practices are pivotal in shaping learners' attitudes toward geometry by influencing both emotional engagement and conceptual understanding [23; 24]. Perceived teacher support, such as encouragement, feedback, and structured guidance, has been shown to significantly enhance learners' motivation and positive disposition toward mathematical tasks [23]. In parallel, learner-centred pedagogies such as collaborative learning, inquiry-based instruction and technology integration improve attitudes by making geometric concepts more accessible and meaningful [25; 26]. Evidence also indicates that structured and developmentally appropriate approaches, including scaffolded instruction aligned with learners' cognitive levels, foster deeper understanding and reduce anxiety, thereby reinforcing positive attitudes [27]. Furthermore, effective teaching practices like clear explanations and guided practice are strongly correlated with improved conceptual grasp, which in turn supports more favourable learner perceptions of geometry [24]. Overall, the literature converges on the view that supportive teacher–learner interactions combined with adaptive pedagogy are essential for cultivating positive attitudes toward geometry.

3.2 Learner engagement and collaboration

Recent empirical studies show that learner engagement and collaboration strongly influence both attitude and achievement in geometry. Active participation in tasks such as inquiry-based learning improves understanding, performance, and confidence in geometry [28]. Collaborative strategies, including group problem-solving, enhance communication

and deepen conceptual understanding, leading to higher achievement [29]. Engagement also shapes attitudes, as interested and motivated learners tend to perform better and view geometry more positively [19]. In addition, collaborative environments increase enjoyment and peer support, which further strengthens both attitude and academic success [30]. Overall, engagement and collaboration work together to improve how learners feel about geometry and how well they perform.

3.3 Motivation, interest and perceived difficulty

Empirical studies consistently show that motivation, interest, and perceived difficulty are key determinants of learners' attitudes toward geometry. High levels of intrinsic motivation and sustained interest are associated with greater engagement, persistence, and positive dispositions toward geometric problem solving, while low motivation often leads to avoidance and negative attitudes [31], [32]. At the same time, learners' perceptions of geometry as difficult or abstract have been found to increase anxiety and reduce confidence, thereby negatively shaping attitudes and performance [33]. Classroom-based research further indicates that when instruction is designed to stimulate interest through interactive tasks, real-life applications, or tools such as GeoGebra, learners are more likely to view geometry as accessible and meaningful, which improves both attitudes and achievement [32], [2]. Large-scale evidence also highlights that reducing perceived difficulty through supportive teaching practices and scaffolding can strengthen motivation and foster more positive attitudes toward geometry over time [2]. Overall, the literature demonstrates that motivation, interest, and perceived difficulty interact dynamically to shape how learners perceive and engage with geometry.

3.4 Technological integration

Recent empirical studies show that technological integration has significantly transformed geometry education by enhancing visualization, interaction, and conceptual understanding [32], [4], [33]. Dynamic geometry software and digital tools enable learners to manipulate shapes and observe real-time changes, which improves spatial reasoning and deepens conceptual grasp compared to traditional methods [33]. Evidence from classroom-based interventions further indicates that the use of platforms such as GeoGebra promotes active learning, increases learner engagement, and supports exploratory problem-solving approaches in geometry [32]. In addition, technology-supported instruction has been found to reduce cognitive load and improve achievement by allowing learners to visualise abstract concepts and receive immediate feedback [31]. Broader large-scale studies also highlight that equitable access to digital resources and teacher preparedness play a critical role in maximizing the benefits of technology in mathematics classrooms [34]. Overall, the literature demonstrates that technological integration not only improves learners' attitudes and engagement but also leads to measurable gains in geometry understanding and performance when effectively implemented.

3.5 Emotional and socio-cultural factors

Recent empirical studies indicate that learners' attitudes toward geometry are strongly influenced by emotional factors such as anxiety, self-efficacy, and prior learning experiences, which can either hinder or enhance engagement. For example, heightened anxiety is consistently linked to negative attitudes and avoidance [31; 33]. At the same time, socio-cultural influences such as classroom environment, teacher support, peer interaction, and cultural beliefs about mathematics shape how learners perceive the relevance and difficulty of geometry [35; 32]. Evidence further shows that supportive and inclusive classroom climates can mitigate negative emotions and foster positive attitudes, while broader societal expectations and access to resources influence motivation and confidence over time [34; 36]. Overall, the literature demonstrates that emotional and socio-cultural factors interact dynamically to shape learners' attitudes toward geometry and their willingness to engage with the subject.

Socio-cultural influences, including gender stereotypes, further shape attitudes toward mathematics [37]. Research indicates that such biases can affect learner participation and self-efficacy, highlighting the need for inclusive and equitable learning environments [38].

4. THEORETICAL FRAMEWORK

This study is grounded in the Community of Inquiry (CoI) framework, which conceptualises learning as the interaction of social, cognitive, and teaching presence [22]. This framework provides a comprehensive lens for examining how learning environments influence learner attitudes by integrating instructional design, interaction, and engagement.

The advantages of using the CoI framework in this study include its comprehensive nature, which allows for examining multiple dimensions of the learning environment. By focusing on social, cognitive, and teaching presence, researchers can identify specific factors that contribute to a conducive learning environment and how these factors influence learners' attitudes towards geometry. Additionally, the CoI framework facilitates the exploration of the interplay between these presences, providing insights into how effective teaching strategies and supportive interactions can enhance learners' engagement and interest in geometry.

5. METHODOLOGY

A quantitative survey design was used to collect data on the relationship between learning environments and learners' attitudes toward geometry. The accessible population comprised 420 learners from seven high schools within a single circuit (Grade 10 = 231; Grade 11 = 189). From this population, a sample of 60 learners was selected using systematic random sampling, which involves choosing a random starting point and subsequently selecting every kth individual from a list [39]. This technique was deemed appropriate due to its efficiency in handling large populations, its simplicity of implementation, and its ability to provide a representative sample while minimizing selection bias [39], [40]. Additionally, systematic sampling enhances data collection efficiency and can yield reliable estimates of population parameters [40], [41], and is often easier to administer than other probability sampling methods [41], [42].

The sample was proportionally drawn from the selected schools, with 20 learners from each school (Grade 10 = 33; Grade 11 = 27). The sampling interval was calculated using the formula $k = \frac{N}{n}$, where N = 420 and n = 60, resulting in $k = 7$. A random starting point was set at learner number 2, after which every seventh learner was selected until the desired sample size was reached.

Qualitative data were collected through semi-structured, face-to-face interviews with ten mathematics teachers. Each interview lasted approximately ten minutes and allowed for flexible questioning and probing to gain deeper insights into participants' views. All interview sessions were audio-recorded with consent to ensure accurate data capture and analysis.

Qualitative data were analysed thematically, while quantitative data were analysed using the Chi-square test to examine statistical associations between variables. Cramér's V was used to determine the strength of these relationships. Reliability analysis using the split-half method produced a coefficient of 0.75, indicating acceptable internal consistency and supporting the reliability of the instrument.

6. RESULTS AND DISCUSSION

6.1 Presentation and analysis of teachers' interview responses

The themes presented in this study were derived through a systematic process of qualitative thematic analysis of the teachers' interview responses. Initially, all interview transcripts were carefully read multiple times to ensure familiarization with the data. Open coding was then employed to identify recurring ideas and patterns related to learners' attitudes toward geometry and the conditions influencing these attitudes. Similar codes were subsequently grouped into broader categories, which were refined into themes based on their conceptual alignment and relevance to the research objectives.

Importantly, the development of themes was both data-driven and theoretically informed. While the initial coding emerged inductively from teachers' verbatim responses, the final themes were organised and interpreted through the lens of the Community of Inquiry (CoI) framework. This allowed the categorization of issues related to instructional practices under teaching presence, learner engagement and understanding under cognitive presence, and interpersonal as well as contextual influences under social presence. This dual approach ensured that the themes remained grounded in the empirical data while also being analytically robust and theoretically meaningful.

Theme 1: Factors contributing to negative attitudes toward geometry

Teachers consistently identified multiple factors influencing learners' negative attitudes. These are illustrated through the following verbatim excerpts:

"Sir, it is their repeated failure in geometry tests, lack of confidence and inability of learners to understand geometry language…" (T2)

"There are so many factors… complexity of the riders, difficulty in memorising the theorems… lack of resources, teachers' pedagogical knowledge…" (T1)

"The belief that geometry is boring and complicated… learners are influencing one another…" (T5)

These responses reflect a breakdown across all three CoI presences. From a cognitive presence perspective, learners' inability to interpret geometric language and analyse problems indicates limited engagement in meaning-making processes. In terms of teaching presence, teachers acknowledge gaps in pedagogical knowledge and instructional design, which constrain effective facilitation of learning. The influence of peers and shared negative beliefs highlights weakened social presence, where classroom interactions reinforce disengagement rather than collaborative learning.

Theme 2: Consequences of negative attitudes

Teachers emphasised the academic and broader consequences of negative attitudes:

"Failure to understand the concepts… ultimately failure in the exams." (T1)

"The learners' negative attitude… contributes a lot to the current high failure rate in mathematics…" (T4)

"Learners… do not fully participate… do not write homework… sometimes… sleep during the lessons." (T10)

These findings strongly indicate diminished cognitive presence, as learners fail to engage in sustained inquiry and understanding. The lack of participation and disengagement also signals weak social presence, where learners do not feel connected or motivated to participate in the learning community. Furthermore, ineffective instructional strategies and limited intervention mechanisms point to insufficient teaching presence, particularly in facilitating active engagement and monitoring learning progress.

Theme 3: Strategies to improve learners' attitudes

Teachers described several instructional strategies:

"*Practically doing the proofs and let the learners discover for themselves…"* (T1)

"I make use of ICT material… to help learners develop positive attitude…" (T2)

"I group learners to solve problems together… learners benefit from each other…" (T5)

These strategies reflect attempts to strengthen teaching presence through improved instructional design (e.g., discovery learning, ICT integration). The use of group work enhances social presence by fostering collaboration and peer interaction. Additionally, inquiry-based approaches promote cognitive presence by encouraging exploration and deeper understanding. However, the data suggest that these practices are not consistently implemented across classrooms, limiting their overall impact.

Theme 4: Resource Constraints and Structural Challenges

Teachers highlighted systemic challenges:

"We are struggling to get textbooks… there is absolutely nothing provided…" (T6)

"In a large class… teachers are unable to correct or encourage learners…" (T7)

"There is no individual attention if class size is too large…" (T8)

These constraints primarily undermine teaching presence, as teachers are unable to design and facilitate effective learning experiences. Overcrowded classrooms and lack of

resources also weaken social presence, limiting meaningful interaction and collaboration. Consequently, cognitive presence is affected, as learners are deprived of opportunities for guided inquiry and conceptual development.

Theme 5: Learner Study Habits and Engagement

Teachers described poor learner engagement:

"Learners are unable to study on their own… only study… before examinations." (T6)

"They cannot study on their own… only good learners… come to teachers for help." (T5)

These findings indicate weak cognitive presence, as learners are not engaging in sustained, self-directed learning. The limited help-seeking behaviour suggests underdeveloped social presence, where learners do not actively utilize collaborative or teacher support structures. This also reflects gaps in teaching presence, particularly in scaffolding independent learning skills.

Theme 6: Parental and Socio-Cultural Influences

Teachers emphasized external influences:

"Parents… do not care… unable to support their children…" (T4)

"Parents… say geometry is difficult… learners come… believing they will not pass…" (T4)

These responses extend social presence beyond the classroom, highlighting the role of family and community in shaping learners' attitudes. Negative parental perceptions reinforce learners' disengagement and weaken their emotional connection to learning. This external social influence indirectly affects cognitive presence, as learners approach geometry with low confidence and expectancy of failure.

Overall, the findings reveal that learners' negative attitudes toward geometry are not attributable to a single factor but rather to systemic misalignment across teaching, cognitive, and social presences. At the same time, teachers demonstrate awareness of effective strategies, structural constraints and inconsistent implementation limit the development of a truly conducive learning environment. This imbalance provides a compelling explanation for the observed weak or null relationship between learning environments and learners' attitudes toward geometry.

6.2 Discussion of the results

6.2.1 Quantitative results

The results indicate a statistically significant relationship between learning environment and learner attitudes toward geometry ($\chi^2 = 53.146$, $p < 0.001$). The effect size ($V = 0.543$) suggests a moderate-to-strong association.

Table 1, Contingency Table - Environment vs Attitude

Attitude towards geometry	**Conducive learning environment**				
	Agree	**Disagree**	**Strongly agree**	**Strongly disagree**	**Total**
Agree	11 61.11	6 33.33	1 5.56	0 0.00	18 100.00
Disagree	20 60.61	11 33.33	2 6.06	0 0.00	33 100.00
Strongly agree	3 60.00	1 20.00	1 20.00	0 00.00	5 100.00
Strongly disagree	1 25.00	0 0.00	1 25.00	2 50.00	4 100.00
Total	**35** **58.33**	**18** **30.00**	**5** **8.33**	**2** **3.33**	**60** **100.00**

Note: Pearson chi-squared = 53.1465; p-value = 0.00003646

Looking at the contingency Table above, you can observe that:
The results show that the p-value = 0.000, since $p < 0.05$, therefore, the null hypothesis:

H_0: There is no significant relationship between a conducive learning environment and learners' attitude towards geometry, which is rejected. For this reason, the alternative hypothesis:

H_1: There is a significant relationship between a conducive learning environment and learners' attitudes towards geometry, which is accepted.

The results indicate that geometry learning and teaching need a conducive environment for the learners to understand the topic conceptually. These results align with those of [23; 24]'s study, which outlined how learners who were nurtured in a healthy environment outperformed their peers in lower supportive environments.

Since the p-value (3.646×10^{-6}) is significantly less than the conventional significance level of 0.05, we reject the null hypothesis. This provides strong statistical evidence of a significant relationship between a conducive learning environment and learners' attitudes towards geometry.

The Contingency Coefficient of 0.685 further supports this conclusion, indicating a substantial relationship between these variables. However, it is worth noting that the chi-square test came with a warning about the approximation. It suggests that some cell frequencies might be too low, which is common in educational data where certain response combinations are rare.

Based on both chi-square analyses conducted, it was revealed that there is a significant relationship between:

Support systems and geometry interest ($\chi^2 = 40.537,\ p = 0.000376$)

Learning environment and geometry attitudes ($\chi^2 = 53.146, p = 3.646 \times 10^{-6}$)

These findings align with previous research demonstrating that supportive and resource-rich environments enhance learner engagement and academic outcomes [31; 33]. The results also support the CoI framework, suggesting that social, cognitive, and teaching presence collectively influence learner attitudes.

6.2.2 Qualitative findings

The qualitative findings of this study provide important insights into the complex relationship between learning environments and learners' attitudes toward geometry, and they largely corroborate, extend, and in some cases challenge existing literature.

Firstly, the finding is that multiple factors, including poor foundational knowledge, difficulty with geometric language, repeated failure, and perceived complexity, shape learners' negative attitudes. This aligns with prior studies that identify geometry as a cognitively demanding domain requiring abstract reasoning and specialized language [1]. Consistent with [8], the results confirm that learners' attitudes are not merely affective reactions but are closely linked to their perceived competence and prior achievement. The prominence of repeated failure and low confidence in the present study reinforces the argument that negative learning experiences significantly shape learners' mathematical dispositions over time.

Secondly, the study found that negative attitudes result in disengagement, poor participation, and low academic performance. This is strongly supported by existing research, which demonstrates that learners' attitudes toward mathematics are significant predictors of engagement, persistence, and achievement [10]. The observed behaviours, such as lack of homework completion, passive participation, and absenteeism, are consistent with findings from [13], who emphasise the reciprocal relationship between emotions, motivation, and academic outcomes. Thus, the current findings reaffirm that negative attitudes toward geometry have both immediate and long-term academic consequences.

Thirdly, teachers' efforts to improve attitudes through strategies such as discovery learning, use of ICT, practical demonstrations, and collaborative learning are consistent with literature advocating for learner-centered and inquiry-based approaches in mathematics education [11; 1]. These approaches are known to enhance both conceptual understanding and positive attitudes by actively involving learners in the learning process. However, the present study extends this literature by showing that such strategies are often implemented inconsistently due to contextual constraints. This suggests that the mere presence of innovative practices does not guarantee improved attitudes unless they are systematically supported.

Furthermore, the study highlights significant structural challenges, including overcrowded classrooms and a lack of teaching and learning resources. These findings align with [4], which identifies resource availability and classroom conditions as critical determinants of effective learning environments. Fraser [12] similarly argues that classroom environment variables like class size, material resources, and teacher support directly influence learner outcomes. The current study adds nuance by demonstrating how these structural limitations specifically hinder the development of interactive and supportive environments necessary for geometry learning.

In addition, the findings related to poor study habits and limited learner autonomy are consistent with research indicating that effective learning in mathematics requires sustained engagement and self-regulated learning strategies [8]. The tendency of learners to rely on memorization and last-minute studying reflects shallow cognitive engagement, which undermines deep understanding of geometric concepts. This supports existing claims

that fostering independent learning skills is essential for improving both achievement and attitudes.

The influence of peer and parental factors identified in this study further supports the growing body of literature emphasizing the role of socio-cultural context in shaping learners' attitudes toward mathematics [13]. Negative peer influence and lack of parental support contribute to the development of unfavourable perceptions of geometry. This confirms the idea that attitudes toward geometry are socially constructed rather than purely individual. This finding strengthens the argument that interventions aimed at improving attitudes must extend beyond the classroom to include family and community engagement.

Finally, while much of the existing literature reports a positive relationship between conducive learning environments and learner attitudes, the findings of this study suggest a more complex reality. Despite teachers' awareness of effective strategies and efforts to create supportive environments, persistent contextual challenges and imbalances in instructional practices appear to limit their impact. This helps explain the null relationship identified in the study and contributes to the literature by highlighting that the effectiveness of learning environments is contingent on the alignment of multiple factors rather than their isolated presence.

6.3 Integrated discussion

Taken together, the quantitative and qualitative findings provide a nuanced and theoretically grounded understanding of the relationship between learning environments and learners' attitudes toward geometry. Quantitatively, the study revealed a statistically significant and moderately strong association between a conducive learning environment and learners' attitudes ($\chi^2 = 53.146$, $p < 0.001$; $V = 0.543$), supporting existing literature which consistently reports that supportive and resource-rich environments positively influence learners' engagement and dispositions toward mathematics [12; 4]. This aligns with prior studies indicating that classroom climate, teacher support, and access to learning resources are key determinants of positive mathematical attitudes and achievement [10].

However, the qualitative findings extend and complicate this understanding by revealing that, in practice, these environments are often constrained by systemic and contextual challenges. For example, overcrowded classrooms, limited teaching resources, inconsistent instructional strategies, and weak learner engagement are common. Interpreted through the Community of Inquiry (CoI) framework, these constraints reflect imbalances across teaching, cognitive, and social presence, which the literature identifies as essential for meaningful learning experiences [22]. Previous research emphasises the importance of learner-centered and inquiry-based approaches in fostering positive attitudes [11; 1]. The present findings highlight that such approaches are not consistently implemented due to contextual limitations, thereby reducing their potential impact.

Furthermore, the qualitative evidence corroborates studies showing that negative attitudes are shaped by prior failure, low confidence, and difficulties with mathematical language [8]. In addition, they are also shaped by socio-cultural influences such as peer pressure and lack of parental support [13]. These factors, which are often underemphasised in quantitative analyses, demonstrate that attitudes are not solely influenced by the presence

of conducive environments but also by how learners experience and interact within those environments.

Thus, the convergence of findings suggests that while a conducive learning environment is statistically associated with positive attitudes, its effectiveness is contingent upon the alignment and integration of instructional quality (teaching presence), meaningful engagement (cognitive presence), and supportive interactions (social presence). This supports and extends existing literature by arguing that the impact of learning environments is not automatic but mediated by contextual realities and implementation fidelity. Consequently, the study contributes to the field by offering a more context-sensitive interpretation of the environment–attitude relationship, particularly within geometry learning.

7. CONCLUSION

This study concludes that while a statistically significant relationship exists between conducive learning environments and learners' attitudes toward geometry, the influence of such environments is complex and context-dependent. Quantitative findings confirm that supportive environments are associated with more positive attitudes; however, qualitative evidence reveals that systemic challenges such as limited resources, overcrowded classrooms, inconsistent pedagogical practices, and weak learner engagement undermine their effectiveness. Viewed through the Community of Inquiry framework, these challenges reflect imbalances in teaching, cognitive, and social presence, which constrain meaningful learning experiences. Therefore, improving learners' attitudes toward geometry requires not only the provision of conducive environments but also the consistent and integrated implementation of effective teaching strategies, active learner engagement, and supportive social interactions within the classroom.

8. RECOMMENDATIONS

Enhancing geometry learning requires a multifaceted approach that integrates technology, strengthens teaching capacity, promotes learner-centred pedagogy and provides targeted support. The purposeful use of digital tools such as dynamic geometry software, simulations and interactive platforms can improve learners' visualisation and conceptual understanding when aligned with instructional goals. At the same time, sustained professional development is essential to equip teachers with strong content knowledge, effective pedagogical strategies and the ability to integrate technology meaningfully. Shifting toward collaborative and learner-centred approaches, such as group work, problem-based learning, and mathematical discussions, can further enhance engagement, reasoning, and communication skills. Complementing these strategies, structured support systems, including peer tutoring, mentoring and supplementary instructional programmes, are critical for addressing learning gaps, building confidence and improving overall achievement in geometry.

9. FUTURE RESEARCH

Future studies should move beyond cross-sectional designs to adopt longitudinal approaches that can better capture how learning environments and attitudes toward geometry evolve over time. There is also a need for intervention-based research that tests specific strategies, for example, the integration of technology (e.g., dynamic geometry software), inquiry-based instruction, and teacher professional development programmes, to determine their causal impact on learners' attitudes and achievement in geometry. Additionally, future research should explore contextual variations, particularly across rural and urban schools, to understand how resource disparities and socio-cultural factors shape learning environments. Given the insights from the Community of Inquiry framework, further studies could examine how balanced integration of teaching, cognitive, and social presence can be practically achieved in mathematics classrooms. Finally, expanding the scope to include parental perspectives would provide a more holistic understanding of the factors influencing attitudes toward geometry.

10. CONTRIBUTION TO THE PUBLIC

This study contributes to the public by highlighting that improving learners' attitudes toward geometry and mathematics more broadly is not solely a matter of learner ability, but is strongly influenced by the quality of the learning environment. The findings underscore the importance of well-resourced schools, effective teaching practices, and supportive classroom interactions in shaping positive educational outcomes. For policymakers and education stakeholders, the study provides evidence that investments in teacher training, classroom resources, and manageable class sizes are essential for improving mathematics education. For parents and communities, the study emphasises their role in fostering positive attitudes by encouraging learners and avoiding negative perceptions about subjects like geometry. Ultimately, the research contributes to broader societal goals by supporting efforts to improve mathematics achievement, which is critical for increasing participation in STEM-related careers and addressing skills shortages in key sectors.

11. LIMITATIONS OF THE STUDY

The study focused primarily on environmental factors without fully accounting for other potentially influential variables, such as prior mathematical achievement, socio-economic background, and teacher experience. These factors may interact with learning environments in complex ways and should be considered in future research.

In addition, while the study acknowledged the role of technology, it did not differentiate between types or quality of technological integration. Future research could explore how specific digital tools (e.g., dynamic geometry software or virtual reality) differentially impact learners' attitudes and engagement.

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