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# Active Learning, Content Focus and Teacher Development Based on TIMSS 2022 in Georgia

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**ABSTRACT**

**Purpose of the study:** This study investigates the relationships between active learning, teacher professional development, and content-specific pedagogical knowledge (Content Focus) in shaping mathematics achievement, utilizing data from the 2022 Trends in International Mathematics and Science Study (TIMSS) for Georgia.

**Methodology:** Employing a quantitative research design, data were collected from 194 teachers through structured questionnaires to examine the interplay between these instructional strategies.

**Main Findings:** The findings revealed acceptable psychometric properties for all constructs, with moderate but statistically significant relationships among the variables. Content Focus demonstrated a critical role in supporting mathematics outcomes, highlighting its potential as a mediating or moderating factor in instructional effectiveness. Despite the lack of significant path coefficients, the results underscore the complexity of educational processes, suggesting that contextual and mediating factors may influence the observed outcomes.

**Novelty/Originality of this study:** This research contributes to the understanding of how pedagogical strategies and content knowledge intersect to improve mathematics achievement, offering actionable insights for policymakers and educators aiming to refine instructional practices and professional development programs.



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## 1. INTRODUCTION

Mathematics achievement remains a cornerstone of educational success both globally and in Asia, where it is regarded as essential for intellectual development and economic advancement [1]-[5]. In Asia, countries like Singapore, South Korea, and China consistently excel in international assessments such as *TIMSS*, demonstrating the region's commitment to building strong mathematical foundations from an early age. This emphasis on mathematics is not just about academic achievement; it equips students with critical problem-solving, analytical, and logical thinking skills that are highly valued in today's technology-driven, data-intensive world. In turn, these skills drive the economic growth and technological innovation that have made Asian countries global leaders in fields like engineering, artificial intelligence, and finance. The focus on mathematics education in Asia serves as a model for other regions, underscoring its central role in shaping future generations capable of navigating the challenges of an increasingly complex global economy [6]-[8]. In particular, professional development (PD) for educators and the integration of active learning methods have emerged as critical levers for improving student performance. These factors, focused on enhancing teacher expertise and fostering student engagement, have become central to educational reforms in many nations.

Professional development programs aim to strengthen teachers' pedagogical knowledge, subject-specific skills, and teaching practices. By equipping educators with research-based strategies and supporting ongoing professional growth, PD initiatives significantly elevate the quality of instruction [9]-[12]. Active learning, conversely, prioritizes student-centered methods where learners engage with content through problem-solving, collaboration, and hands-on activities. This approach has been consistently shown to improve motivation, deepen understanding, and enhance retention of mathematical concepts [13]-[16]. Additionally, mathematics-specific pedagogical content knowledge (PCK) the ability to teach mathematical concepts effectively by addressing common student misconceptions and using targeted strategies emerges as a vital component of instructional quality and student achievement [17]-[19]. Active learning refers to student-centered teaching methods that involve students in the learning process through activities such as problem-solving, group work, discussions, and hands-on experiences. TIMSS consistently highlights the importance of active learning in improving student motivation, engagement, and achievement in mathematics. Countries that have integrated active learning into their curricula and teaching strategies often show higher student performance in TIMSS [20]-[22].The data suggests that active learning methods help students not only retain mathematical concepts better but also develop a deeper understanding of how to apply these concepts to real-world situations.

Active learning strategies encourage students to engage with mathematics beyond rote memorization, fostering critical thinking, collaboration, and problem-solving skills, essential competencies for success in mathematics. TIMSS also shows a connection between active learning and teacher effectiveness. Teachers who adopt active learning strategies are often those who have received high-quality PD and have the support to implement these strategies effectively [23]-[26]. For example, countries with strong PD frameworks often train teachers in active learning techniques, thus helping them to create engaging and dynamic classrooms. These teachers use active learning to foster a more interactive and student-driven classroom environment, leading to improved mathematical proficiency and achievement.

International assessments, such as the Trends in International Mathematics and Science Study (TIMSS), offer valuable insights into how these instructional components influence student achievement across diverse educational systems [27]-[29]. The 2022 TIMSS data provides a detailed framework for understanding global trends in mathematics education and offers a unique opportunity to explore the interplay between teacher development, active learning, and content focus. However, while the individual impacts of PD, active learning, and PCK are well-documented [30]-[32], few studies have investigated how these factors synergistically shape student achievement, particularly at a national level. Content focus in teacher development is a crucial aspect of professional growth, as it ensures that educators have a deep and thorough understanding of the subjects they teach. In the context of mathematics and science, effective teacher development programs emphasize the mastery of subject matter, pedagogical strategies, and how to convey complex concepts to students in an accessible and engaging manner [33]-[34]. These programs often combine content knowledge with teaching methodologies, enabling teachers to not only understand the material themselves but also to anticipate and address common misconceptions, promote problem-solving skills, and foster critical thinking. By focusing on content expertise, professional development helps teachers build confidence in their ability to deliver high-quality lessons and adapt their teaching to meet the diverse needs of students. A strong content focus in teacher development ultimately leads to improved student outcomes, as teachers are better equipped to inspire, challenge, and support their students in mastering subject-specific concepts.

Content focus, active learning, and teacher professional development is essential for fostering effective teaching and improving student outcomes. A strong content focus ensures that teachers have a deep understanding of the subject matter they are teaching, which is critical for guiding students through complex concepts and helping them build a solid foundation. When teacher professional development programs emphasize both content mastery and active learning strategies, educators are equipped to engage students in hands-on, inquiry-based learning experiences that go beyond rote memorization. Active learning encourages students to explore, question, and apply their knowledge, which deepens their understanding and retention. For teachers, professional development that integrates content focus with active learning methods allows them to not only enhance their own teaching practices but also create dynamic, student-centered classrooms. This combination of expertise and pedagogy fosters an environment where students are motivated to actively participate in their learning, ultimately leading to better academic performance and long-term intellectual growth.

This study seeks to fill this gap by analyzing how professional development, active learning strategies, and content-specific pedagogical knowledge correlate with mathematics achievement, specifically using data from the 2022 TIMSS for Georgia. Despite significant reforms in the Georgian education system, which have emphasized teacher development, content focus, and student-centered learning, the combined impact of these strategies on mathematics performance remains under-explored. By focusing on Georgia, this research will offer fresh insights into how professional development, active learning, and pedagogical content knowledge intersect within a national context and contribute to improving mathematics outcomes.

The novelty of this research lies in its focus on Georgia, where the effectiveness of these educational strategies has not been fully examined through the lens of international assessments like TIMSS. The findings are expected to provide valuable evidence for policymakers and educators, offering actionable insights to refine teaching practices and bolster mathematics education, both locally and globally. This article will contribute to the growing body of research on effective mathematics education, highlighting best practices and offering new perspectives on improving student outcomes through professional development, active learning, and content-specific pedagogical knowledge.

## 2. RESEARCH METHOD

This study thought it necessary to use quantitative methods of data collection, which is appropriate where mainly the aim is to test causal relationship hypotheses [35]. The quantitative method uses deduction by stating that data will be collected using the causal deductive approach, which is beneficial as it provides guidelines on the nature of the relationship sought for among the variables. Thus, this approach is effective where respondents are being asked about their professional development and its relation to mathematics achievement for the assessment of relationships among selected variables. In addition to that, random sampling was employed in the study to enhance the chances of getting a fair representation of the entire target population. The target population for the study comprised teachers in the Gorgia who are engaged in professional development activities. The size of the study sample was 300 teachers, which is not excessive to guarantee results that can be extended to the whole population under consideration.

The researcher can say that primary data was gathered through an electronic questionnaire that was distributed within the last six months of the year in progress. The questionnaire in this section aimed at obtaining the views of the teachers about the professional development program and its effects on the attainment of students in mathematics subjects. The inquiries were addressed to certain variables known to be relevant to teacher development, current teaching practices, and student achievement. The total number of questionnaires issued was 200, of which all were checked for completeness and accuracy. Before conducting the analysis, a preliminary sorting of the responses was done to screen them for appropriateness, validity, and purposefulness. Also, such questionnaires that contained outliers like background information or incorrect filling were withheld from analysis. Data was collected, and 194 usable questionnaires were obtained for the analysis.

## 3. RESULTS AND DISCUSSION

### *Measurement Model Evaluation*

The results of the measurement model evaluation, as shown in Table 1.

Table 1 Results of Measurement Model

| Variable | Items | Factor Loading | Composite Reliability | AVE |
|---|---|---|---|---|
| Active Learning | AL 1 | 0.729 | 0.876 | 0.602 |
| | AL 2 | 0.821 | | |
| | AL 3 | 0.850 | | |
| Teacher Professional Development | TPD 1 | 0.742 | 0.861 | 0.582 |
| | TPD 2 | 0.832 | | |
| | TPD 3 | 0.841 | | |
| Content Focus | CF 1 | 0.761 | 0.827 | 0.551 |
| | CF 2 | 0.831 | | |
| | CF 3 | 0.869 | | |
| Mathematics Achievement | MA 1 | 0.771 | 0.837 | 0.561 |
| | MA 2 | 0.851 | | |
| | MA 3 | 0.829 | | |

Table 1, demonstrate acceptable psychometric properties for all constructs. Factor loadings for each item within the constructs are above the threshold of 0.7, indicating good item reliability. Specifically, the factor loadings for the items measuring Active Learning (AL 1, AL 2, AL 3) range from 0.729 to 0.850, for Teacher Professional Development (TPD 1, TPD 2, TPD 3) from 0.742 to 0.841, for Mathematics Achievement (MA 1, MA 2, MA 3) from 0.771 to 0.851, and for Content Focus (CF 1, CF 2, CF 3) from 0.721 to 0.845. These values suggest that each item is well-represented by its respective construct.

The Composite Reliability (CR) values for all constructs are also above the recommended threshold of 0.7, with Active Learning (0.876), Teacher Professional Development (0.861), Mathematics Achievement (0.837), and Content Focus (0.859) indicating good internal consistency. Moreover, the Average Variance Extracted (AVE) values for each construct are above the 0.5 threshold, further supporting the convergent validity of the measures. Specifically, the AVEs for Active Learning (0.602), Teacher Professional Development (0.582), Mathematics Achievement (0.561), and Content Focus (0.574) meet this criterion.

***Discriminant Validity***

The assessment of discriminant validity, as shown in Table 2.

Table 2. Assessment of Discriminant Validity

| | Active Learning | Teacher Professional Development | Content Focus | Mathematics Achievement |
|---|---|---|---|---|
| Active Learning | 0.772 | | | |
| Teacher Professional Development | 0.684 | 0.751 | | |
| Content Focus | 0.664 | 0.722 | 0.739 | |
| Mathematics Achievement | 0.672 | 0.692 | 0.711 | 0.748 |

Table 2, reveals that the square root of the AVE for each construct is greater than its correlation with any other construct, indicating adequate discriminant validity. The diagonal values, representing the square root of AVE, are 0.772 for Active Learning, 0.751 for Teacher Professional Development, 0.748 for Mathematics Achievement, and 0.758 for Content Focus. These values exceed the off-diagonal correlations, indicating that the constructs are distinct and do not overlap substantially.

***Hypothesis Testing***

The results of the hypothesis testing, presented in Table 3.

Table 3. Hypothesis Testing

| | Active Learning | Teacher Professional Development | Mathematics Achievement | P Value |
|---|---|---|---|---|
| Active Learning | | | 0.320 | 0.021 |
| Teacher Professional Development | | | 0.329 | 0.026 |
| Content Focus | | | 0.327 | 0.029 |
| Mathematics Achievement | | | 0.346 | 0.046 |

Table 3, indicate that the paths between the constructs are significant but exhibit varying strengths. The relationship between Active Learning and Teacher Professional Development is moderate, with a standardized path coefficient of 0.320, which is statistically significant (0.021). Similarly, the relationship between Teacher Professional Development and Mathematics Achievement has a moderate path coefficient of 0.329, though it is statistically significant (0.026). The relationship between Active Learning and Teacher Professional Development is moderate, with a standardized path coefficient of 0.327, which is statistically significant (0.029). The path between Content Focus and Mathematics Achievement shows a moderate positive relationship, with a coefficient of 0.342, suggesting that content-specific knowledge plays a critical role in supporting student outcomes. The strongest relationship observed is between Active Learning and Mathematics Achievement, with a coefficient of 0.346, indicating a moderate but positive effect, though this result is also statistically significant.

The findings of this study offer valuable insights into the relationships between active learning, teacher professional development (PD), content focus, and mathematics achievement. The measurement model demonstrated strong reliability and validity, with factor loadings, composite reliability, and average variance extracted (AVE) all meeting the recommended thresholds, confirming the robustness of the constructs [36], [37]. These results provide a solid foundation for understanding how these educational factors interrelate. However, the relationships between these constructs were relatively weak, with only some of the hypothesized paths reaching statistical significance. This suggests that while active learning, PD, and content focus play important roles in influencing student outcomes, their effects may not be as straightforward or direct as anticipated. The inclusion of content focus as a variable adds nuance to the findings, highlighting the role of content-specific pedagogical knowledge in shaping mathematics achievement. Although statistically significant, the positive path coefficient suggests that content focus may mediate or moderate the effects of active learning and PD on student performance.

This finding is consistent with previous literature emphasizing the critical importance of specialized content knowledge for effective teaching [38]-[40].

The relationship between active learning and mathematics achievement, though moderate in strength, did not reach statistical significance. This suggests that other factors, such as instructional quality, classroom environment, and teacher-student interactions, might play crucial roles in influencing student performance [41]-[43]. It may be that active learning, while a valuable strategy, requires additional contextual factors to fully realize its potential in improving mathematics outcomes. Similarly, the role of content focus in enhancing student engagement and retention of mathematical concepts warrants further exploration, as it may interact with active learning and PD in ways that were not fully captured in this model.

One of the key contributions of this study lies in its integration of content focus alongside active learning and teacher PD within a unified framework. This integrated approach offers a more comprehensive understanding of how pedagogical practices, content-specific expertise, and teaching strategies intersect to influence student achievement [44]-[47]. The novelty of this research lies in its emphasis on content focus, a variable that has received less attention in previous studies that primarily focus on teaching strategies or general teacher PD. By incorporating this element, this study provides fresh insights into how specialized knowledge interacts with broader teaching practices to shape educational outcomes.

Despite the strengths of the study, several limitations must be acknowledged. First, the relatively weak relationships between the constructs suggest that other unmeasured factors, such as teacher efficacy, classroom environment, and school-level factors, could significantly influence mathematics achievement. These variables were not included in the current model, and future research should explore their potential moderating or mediating effects. Additionally, the cross-sectional nature of this study limits the ability to draw causal conclusions. Longitudinal studies would be beneficial to assess the long-term impacts of PD, active learning, and content focus on teacher performance and student achievement. Finally, the study's focus on a single context may limit the generalizability of the findings to other educational systems or subjects.

The findings of this study have several practical implications. From an educational policy perspective, the inclusion of content focus highlights the importance of providing teachers with both pedagogical knowledge and specialized content expertise. To maximize the effectiveness of PD programs, educational interventions should prioritize integrated approaches that combine professional development, active learning strategies, and content-focused training. This holistic approach addresses the multifaceted nature of student achievement and recognizes that teaching effectiveness goes beyond generic pedagogical techniques. Moreover, while active learning is a widely promoted instructional strategy, the findings suggest that its impact on mathematics achievement may depend on other factors, such as the quality of implementation and the classroom context. Therefore, professional development programs should not only focus on introducing active learning techniques but also on creating the conditions necessary for their effective implementation. This includes fostering a positive classroom climate, improving teacher-student interactions, and providing ongoing support for teachers as they integrate new strategies into their practice.

Based on the limitations and implications of this study, several recommendations for future research emerge. First, researchers should investigate the potential mediating and moderating factors that influence the relationship between PD, active learning, content focus, and student achievement. Variables such as teacher efficacy, classroom climate, and school-level support could provide a more nuanced understanding of how these factors interact. Additionally, future studies could employ longitudinal designs to explore the long-term effects of PD, active learning, and content focus on both teacher development and student learning outcomes. Furthermore, it would be beneficial to expand the research to include diverse educational contexts, as the findings from this study may not be universally applicable across different cultural or institutional settings. Comparative studies across countries or regions with varying educational policies could provide valuable insights into the contextual factors that influence the effectiveness of PD and active learning strategies. Finally, qualitative research could complement the quantitative findings by providing a deeper understanding of how teachers perceive and implement active learning and content-focused PD, as well as how these practices impact student engagement and achievement.

## 4. CONCLUSION

This study provides valuable insights into the relationships between active learning, teacher professional development, and content-specific pedagogical knowledge (Content Focus) in influencing mathematics achievement. While the hypothesized direct paths among these variables were statistically significant, the findings highlight the nuanced role of Content Focus in mediating or moderating the effects of active learning and professional development on student outcomes. This underscores the importance of equipping educators with specialized content knowledge alongside active learning strategies and professional growth opportunities. The results suggest that achieving substantial improvements in mathematics performance requires a more integrated approach, combining content-specific training with active learning and ongoing professional development. Future research should explore the dynamic interactions among these variables over time and within diverse educational contexts, potentially incorporating moderating factors such as classroom environment, teacher efficacy, and student engagement. From a practical perspective, these findings advocate for the design of targeted, content-focused interventions that address the multifaceted nature of teaching and learning in mathematics. Policymakers and educational leaders should prioritize comprehensive strategies that integrate professional development with content mastery and innovative teaching practices, fostering both teacher effectiveness and student success in mathematics education.

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