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Mathematical Rigor at Primary Level in Pakistan: Teachers Problems and Prospects

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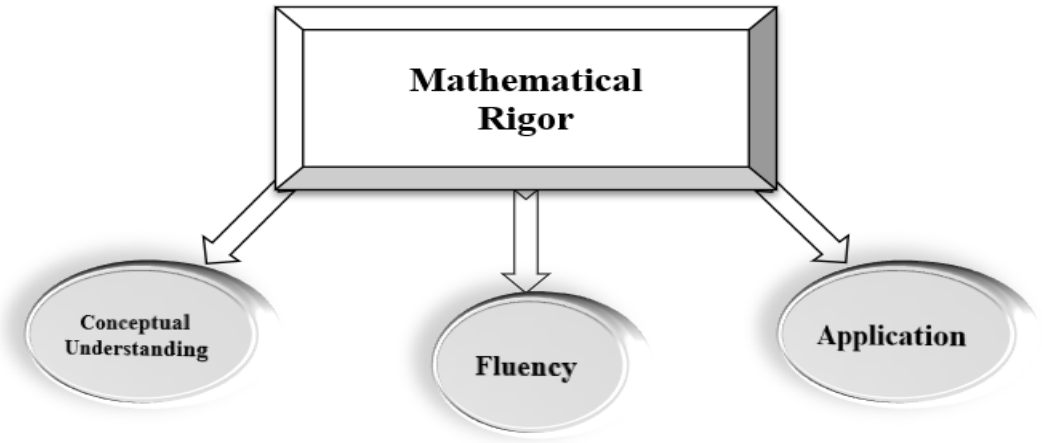
Abstract
The importance of teachers in the contemporary world has assumed novel manifestations due to the advent of the modern period. The main purpose of this research study was to investigate the mathematical rigor at primary level in the district Khushab, Punjab Pakistan: Teachers Problems and Prospects. Study employed a descriptive quantitative design. The population of the study was all the mathematic teachers of grade three at public primary schools and random sampling technique was used for sample selection. The sample (210) represents 30% of the population. The self-developed Likert type questionnaire was used to collect data. A questionnaire was about students' mathematical rigor with 18 items. The value of Cronbach's alpha for students' mathematical rigor questionnaire was 0.89. The findings revealed that most of the teachers perceived that they have good level to foster student's mathematical rigor. Results indicated that students possess a noteworthy degree of mathematical rigor, which were shown by their solid conceptual understanding of mathematical ideas, high level of fluency, and fluent application of these concepts. However, the range of differences identified in fluency and application scores highlights the need for ongoing endeavours to guarantee uniformity and thoroughness in mathematical skills across various situations.

Key words: Mathematical Rigor, Conceptual Understanding, Fluency, Application, Primary School Teachers

Introduction

The usage of technology in the classroom has made teachers even more essential in today's society. They are responsible for educating the students, but they also have a duty to assist them in applying what they have learned to improve their skills. It is essential to hire teaching faculty who possess the necessary instructional expertise to impalement the change and raise educational standards if teachers are dedicated to pursuing a change that is genuinely productive, improving the quality of education, and raising the level of student's success. The effectiveness of any education system is dependent on the availability of teachers who have instructional abilities (Sulaiman & Ismail, 2020). It is a very well-known truth that a school's teachers are better at their jobs than the educational system itself; hence, a school's teachers are the primary reason why their school is successful.

Students are assisted in their learning by teachers. The significance of teaching is a crucial factor in the enhancement of learning that takes place in educational settings(Smith & Gillespie, 2023).
Known as the “mother of science,” mathematics is always crucial and required the subject to be taught at the basic level in all schools around the world. The most significant element affecting how well mathematics is taught in the classroom is the teacher. A well-prepared teacher with good presenting skills and the required audio-video aids may successfully introduce changes in the mathematics curriculum and pedagogy (Omariba, 2022). The most important responsibility that mathematics teachers should take on is to get the next generation ready to understand and confront the effects of globalization (Bosio & Olssen, 2023).
Rigor is necessary for mathematical mastery, it cannot take the place of other components that are necessary for a successful curriculum (Guillaume, 2021). Visualize a rope with five strands that are dependent on one another and entwined with one another (Hull, Balka & Miles, 2013). This is the metaphor that researchers think might be used to illustrate the function that rigor plays in a successful mathematics course. Because students with rigor can never give up easily in problematic situations regarding learning of mathematical skills (Chamberlin & Schultz, 2021). These skills in students make them mathematically equipped and fully divergent thinkers. Pupils can participate more actively in the learning process when their teachers have strong instructional abilities, understand how to enhance and boost students’ mathematical rigor (Timm & Barth, 2021).
Moreover, mathematical rigor characterized by accurate reasoning, logical problem-solving, and conceptual depth is sometimes insufficiently developed in students as a result of inefficient teaching methods (Stein et al., 2009). Hussnain (2020) stated that the results with instructional technologies were worse than those of traditional instructions. This was since teachers were not trained in the use of instructional technologies for the teaching of mathematics. When it comes to the preparation of pupils for mathematical skills, government schools that have little or no access to technology encounter a variety of challenges. The lack of technology in government schools presents teachers with a variety of challenges; thus, there is a pressing need to improve teachers' instructional abilities so that they may successfully navigate these challenges for students’ mathematical rigor in learning mathematical skills.



According to the definition that was provided by the National Research Council (2001), pupils are considered to have developed procedural fluency when they have the “calculation skills for processes flexibility, correctly, efficiently, & properly”. For example, in mathematics, this indicates that students can perform operations such as adding, subtracting, multiplying, and dividing numbers precisely and with self-assurance.Students are required to show "comprehension of mathematical ideas,

operations, and relations" (National Research Council, 2001). Students demonstrate a grasp of the quadratic equation in algebra by demonstrating that they know when to use it, how to solve it, how to interpret the results, and how to employ them. Students are required to demonstrate a comprehension of when to employ a specific inference test, describe the assumptions, and show how to evaluate and use the findings in the subject of mathematics.

According to research published by the Carnegie Foundation for the Advancement of Teaching (Silva & White, 2013), students who effectively interact with their coursework demonstrate persistence in problem solving and utilize a range of efficient learning techniques. For instance, they are interested in locating useful materials, they are driven to struggle with an issue until they discover a solution to it, and they are eager to analyze their own work to spot mistakes. Students can appropriately apply their mathematics knowledge to new contexts, according to research conducted by (National Governors Association Center for Best Practices and the Council of Chief State School Officers, 2010). Algebraic applications in calculus, such as differentiating exponentials, are one example. Students can communicate effectively and express their work in a manner that is both clear and precise by using mathematical language. For mathematical rigor, students are required to show what they have done is effective, when it is effective, and why the approach they picked is acceptable. A response to the question "How do we know?" may be given by the student. Students studying calculus, for instance, should not link derivatives with the rote technique (such as dxn/dx = nxn-1), but rather with the idea of instantaneous rate of change. In a similar manner, using the statistics example from earlier, students should not identify the inference test with the computation of the t-score but rather with the notion of population, sample characteristics, and other issues that are created from the calculation (Cobb, 2018).

To be capable of teaching pupils' mathematical skills, teachers need to have specific skills in the disciplines of mathematics. In addition, teachers rely on more traditional teaching strategies to instruct students in mathematical skills. This study seeks to identify students' mathematical rigor, emphasizing the identification of effective instructional strategies that improve conceptual understanding in mathematics classrooms. Mathematical teachers often encounter considerable difficulties in improving students' comprehension of fundamental mathematical concepts. Chapman (2015) asserted that teachers need rigor to convey mathematical concepts as understandable learning experiences. May teachers' have difficulties in using tactics that foster deep mathematical understandings, resulting in students depending on rote memorization instead of achieving conceptual understanding (Jensen, 2017).

Previous studies were conducted in this area based on the national mathematical curriculum of Pakistan (Asad et al., 2020). The purpose of this research study was to investigate the mathematical rigor at primary level in the district Khushab, Punjab Pakistan: Teachers Problems and Prospects. In Pakistani primary schools, where a habitual culture of mathematics teaching is winning, this research may be beneficial for mathematics teachers to improve teachers' instructional abilities. Unfortunately, currently in Pakistan the students are not proficient in mathematics, majority of students failed or passed this subject with average grades (Wenr, 2020). Teachers must possess the instructional skills required to provide students opportunities for mathematical rigor, if they are to help them improve their mathematical skills (Mrayyan, 2016). At primary school level the aim of teaching mathematical rigor is to produce such students, who have ability to cope with the real-world challenges. Hence, it is vital to examine the students' mathematical rigor at primary level in the district Khushab.

Objectives of the Study

The study had the following key objectives:

1. To examine the mathematical rigor of students at primary level.

2. To find out the problems faced by mathematics teachers at primary level.

Research Questions

1. What are the approaches to measure mathematical rigor of students at primary level?
2. What are some tentative solutions about problem faced by mathematics teachers?

Methodology:

Descriptive quantitative research design was employed to find out the perception of mathematics teachers.

Population

The population in the study were all grade three mathematics teachers working in Public primary schools in Pakistan's Punjab region.

Sample & Sampling Technique

The sample was selected using the random sampling technique. The sample consisted of 210 math teachers in Khushab, of whom 158 were male and 52 were female.

Research Tool

To measure student's mathematical rigor of grade three students a self developed questionnaire was used to collect data from mathematics teachers. Cronbach alpha (0.89) for the students' mathematical rigor questionnaire administered to mathematics teachers was considered highly reliable. While the reliability statistics of the Students' Mathematical Rigor (SMR) questionnaire indicated a consistent level of internal reliability across all factors. The reliability of Conceptual Understanding, Fluency, and Application were high, as shown by Cronbach's alpha values, which range from 0.75 to 0.84. The coefficients indicated that the items within each component consistently measured the desired construct, demonstrating reliability in measuring students' mathematical rigor.

Data Collection

Data was collected personally by visiting the selected schools. The selected teachers were asked to response the questionnaire which was provided to them. Data was analyzed through Statistical Program for Social Sciences (SPSS). Descriptive statistical (percentages, mean values) techniques were used to interpret the numerical data.

Data Analysis

The study utilized the SMR tool to collect data from primary school mathematics teachers' perception.

Figure 1.1 Teachers Perceptions regarding "Conceptual Understanding" on Students' Mathematical

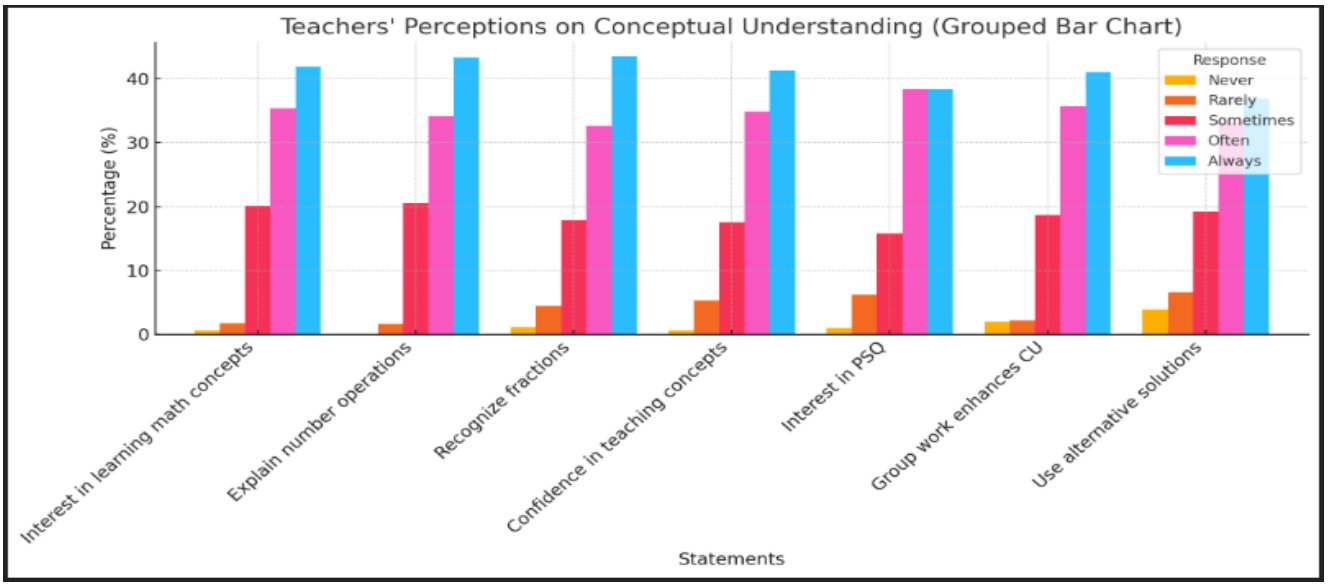


Figure 1.1 bar chart titled *"Teachers' Perceptions on Conceptual Understanding"* presents an analysis of how frequently teachers observe key indicators of conceptual understanding among students across seven mathematical domains. These domains include interest in learning math concepts, explaining number operations, recognizing fractions, confidence in teaching concepts, interest in problem-solving questions (PSQ), enhancement of conceptual understanding through group work, and the use of alternative solutions. The data is categorized into five response levels: *Never*, *Rarely*, *Sometimes*, *Often*, and *Always*. Overall, the chart reflects a predominantly positive perception among teachers, with the majority indicating that students *"Always"* or *"Often"* demonstrate conceptual understanding. Particularly high percentages in the *"Always"* category—exceeding 40%—were noted in recognizing fractions, explaining number operations, and confidence in teaching concepts. The *"Often"* category also shows strong representation, typically ranging between 30% and 38%, suggesting frequent student engagement with these concepts. Conversely, the *"Never"* and *"Rarely"* categories are minimally represented, generally falling below 5%, which indicates that very few teachers perceive a complete absence of understanding. Some variation is noted in statements like using alternative solutions and initial interest in learning math, where the *"Sometimes"* response is more prevalent, pointing to potential areas for pedagogical focus. In conclusion, the chart suggests that teachers generally perceive a high level of conceptual understanding among their students, with most reporting consistent or frequent evidence of key mathematical thinking skills in the classroom.

Figure 1.2 Teachers Perceptions about "Fluency" on Students' Mathematical Rigor

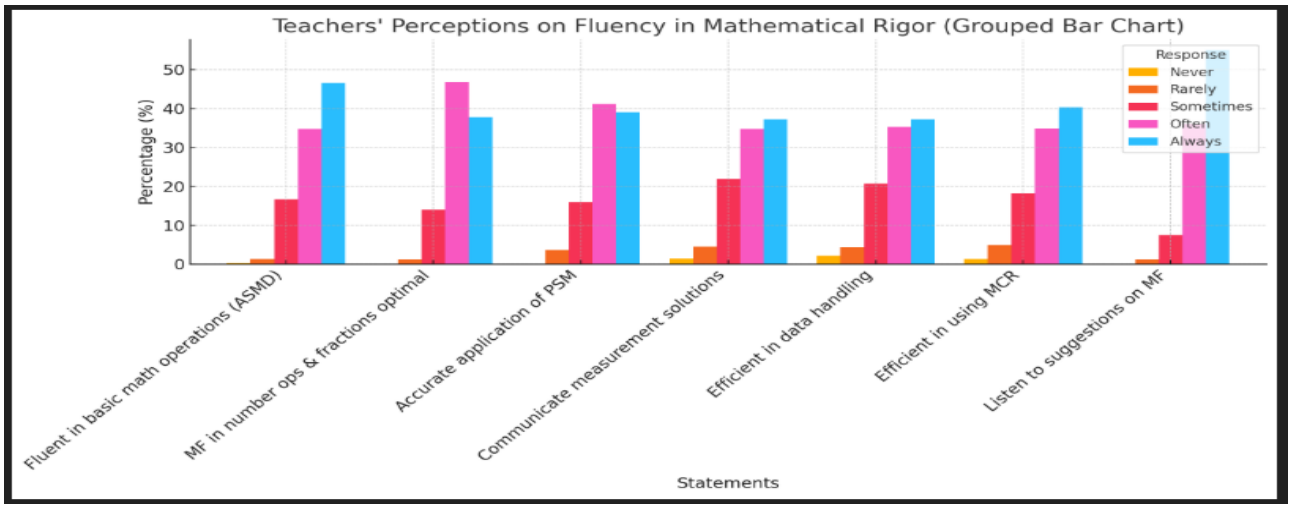


Figure 1.2 bar chart titled *"Teachers' Perceptions on Fluency in Mathematical Rigor"* displays data on how frequently teachers observe various indicators of mathematical fluency and rigor among students. The chart includes seven key statements that represent different aspects of mathematical proficiency: fluency in basic math operations (ASMD), number operations and fraction optimization, accurate application of problem-solving methods (PSM), communication of measurement solutions, data handling, use of mathematical communication and reasoning (MCR), and responsiveness to feedback or suggestions in math.

The data reveals a positive trend, with the highest percentages concentrated in the *"Always"* and *"Often"* categories. For instance, the highest *"Always"* response, around 45% or more, was observed in fluency with number operations and fractions, indicating strong perceived competence in this domain. Similarly, a large proportion of *"Often"* responses (35–45%) were noted across most categories, particularly in the accurate application of problem-solving methods and use of MCR, suggesting that these skills are frequently observed by teachers in their students. Conversely, the *"Never"* and *"Rarely"* responses remain consistently low, typically under 5%, indicating that teachers seldom find students completely lacking in these competencies. A moderate presence of *"Sometimes"* responses in areas such as communication of measurement solutions and efficient data handling highlights some variability, suggesting that while these skills are present, they may not be consistently demonstrated by all students.

Figure 1.3 Teachers Perceptions regarding "Application" on Students' Mathematical Rigor

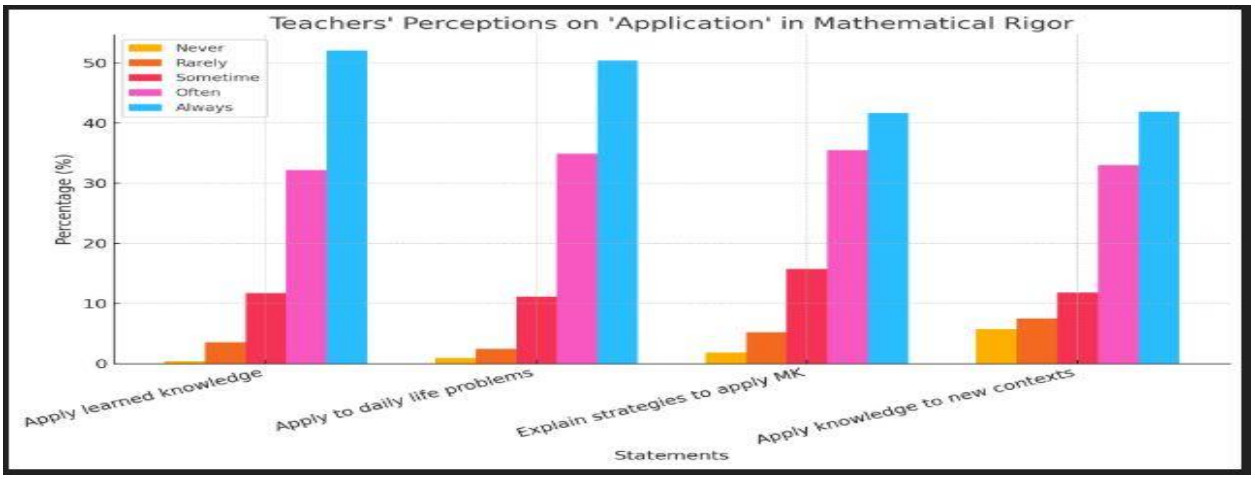


Figure 1.3 bar chart titled *"Teachers' Perceptions on 'Application' in Mathematical Rigor"* illustrates how frequently teachers observe students applying mathematical knowledge in various practical and academic contexts. The five key areas assessed include applying learned knowledge, solving daily life problems, explaining strategies for applying mathematical knowledge (MK), and transferring knowledge to new contexts. Teacher responses are grouped into five categories: *Never*, *Rarely*, *Sometime*, *Often*, and *Always*. Overall, the chart reflects a highly positive perception, with the majority of teachers selecting *"Always"* and *"Often"* for all statements. In particular, more than 50% of teachers reported that students *"Always"* apply their knowledge to daily life problems, indicating strong real-world relevance of mathematical learning. Similarly, high percentages in the *"Always"* and *"Often"* categories for other statements, such as applying knowledge to new contexts and explaining strategies, suggest that students are generally able to extend and articulate their understanding beyond the classroom. While the *"Sometime"* category shows moderate representation—especially in explaining strategies and transferring knowledge—this suggests some inconsistency in how regularly all students demonstrate these higher-order thinking skills. The *"Rarely"* and *"Never"* responses remain minimal across all statements, indicating that few teachers perceive a complete lack of application skills among their students.

Findings

The following findings were drawn from the teachers' perception of students' mathematical rigor:

1. The mean score (Mean= 4.10, SD=0.91) reflected uniform evaluations of students' conceptual understanding. Approximately 40.92% of teachers consistently acknowledged a high level (always) of student involvement, attention, and proficiency in mathematical concepts, indicating the efficacy of instructional strategies in promoting conceptual understanding related to students' mathematical rigor.
2. The results indicated an overall mean score (Mean=4.17, SD=0.84), reflecting strong perceptions of students' fluency in mathematical rigor. Teachers consistently (41.92%) assessed students as always demonstrating proficiency across all dimensions, with the greatest marks noted in students' receptiveness to concepts and their capability to execute basic mathematical operations. The findings emphasized the need to cultivate fluency in both fundamental and advanced mathematical skills to improve overall students' mathematical rigor performance.
3. Most teachers (46.52%) perceived students as always proficient in using mathematical knowledge to resolve mathematical problems, with an overall mean score (Mean=4.18, SD=0.95). This indicated that pupils have shown competence in applying theoretical knowledge to practical problem-solving.

The findings showed that students understood fundamental concepts in mathematics rather well. The average result on the fluency test, which is a crucial part of mathematical ability, was (Mean= 4.17, with a standard deviation (SD=0.84). The majority of pupils seemed to have a great aptitude for mathematical operations, as shown by the high average score and fairly significant standard deviation. Nonetheless, there were significant differences in the ability of every individual level. Furthermore, the mean score for the application indicator, which gauges the capacity to apply mathematical concepts in practical contexts, was (Mean=4.18), with a standard deviation of (SD=0.95). This implies that a high level of application skills was present. In summary, the findings demonstrated that students had a significant level of mathematical rigor, as shown by their strong conceptual grasp of mathematical topics, high fluency, and fluent application of these concepts. However, the variety of variations seen in application and fluency scores emphasizes the need of continuous efforts to ensure consistency and comprehensiveness in mathematical skills across many contexts.

Discussion

This study examined the mathematical rigor at primary level in the district Khushab, Punjab Pakistan: Teachers Problems and Prospects.The results indicated that well trained teachers, who employ diverse instructional techniques, play a crucial role in enhancing students' ability to engage with mathematical concepts at both a procedural and conceptual level. Mathematical rigor involved precision, logical structuring and deep understanding, which are best cultivated thorough high quality pedagogical competencies. Research by (Hunter & Crespo, 2019) indicated that structured and conceptually rich mathematics instructions foster deep learning, enhancing students' abilities to engage critically with mathematical concepts. The study also corroborates previous research on the significant of professional development for teachers. Darling-Hammond (2020) asserts that ongoing professional development initiatives that emphasize pedagogical improvement lead to better learning results for students, especially in math. In a similar vein, Lynch, Chin, and Blazar (2017) stress that in order to provide rigor in mathematics teaching, teachers must combine organized problem-solving techniques with chances for

exploratory learning. The results of this research support these viewpoints, indicating that methods that strike a balance between mathematical rigor and instructional design should be included into professional development for teachers of mathematics. In summary, the results are consistent with previous research that highlights the significance of good teaching practices in forming students' mathematical aptitudes. Teachers may improve students' mathematics learning in both the analytical and creative domains by using inquiry-based and organized teaching strategies, which will eventually increase their total mathematical competency.

Conclusion and Recommendations

It is necessary to carefully consider teaching strategies, assessment methodologies, and the cognitive problems that pupils face in order to assess the mathematical rigor of primary education. Teachers may effectively evaluate and improve the mathematical rigor of primary school pupils by using problem-solving exercises, performance evaluations, extended answer questions, rubrics, and realistic assignments into their teaching and assessment strategies. These methods improve the development of critical thinking skills and a deeper understanding of mathematical concepts in addition to offering helpful insights into students' mathematical reasoning and cognitive processes. Additionally, teachers may provide a strong foundation for students' future success in mathematics and other subjects by encouraging a culture of mathematical rigor in elementary schools. The study's recommendations were as follows:

1. Resources should be allocated by planning and policy bodies to the creation of thorough teacher training programs that are intended to improve teaching skills.
2. 2. In order to include projects and activities, cooperation between curriculum developers and teacher education institutes is required. This might include developing open-ended problem-solving tasks, including practical applications of mathematical principles, and encouraging student-led research and inquiry.
3. Planning and policy organizations should assist in providing teachers with chances for ongoing professional development so they may enhance their methods and abilities that develop student's mathematical rigor.
4. These might include conferences, seminars, and workshops that concentrate on effective teaching strategies, evaluation techniques, and classroom management practices.
5. In order to explore and create innovative approaches to teaching and learning mathematics, teacher education institutions should aggressively promote interdisciplinary collaboration between educators, mathematicians, psychologists, and other stakeholders.
6. By using these concepts, planning and policy organizations as well as teacher education programs may significantly influence the promotion of innovation in mathematics education. As a result, students may be able to acquire the skills necessary to assess and analyze data, solve challenging issues, and learn new things throughout their life, preparing them for success in the fast-paced and dynamic society of the twenty-first century.

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