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Developing And Validating Middle School Mathematics Teachers' Pedagogical Competency Scale

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ABSTRACT

This study aims to design, develop, and validate a comprehensive measuring tool to assess the pedagogical competencies of middle school mathematics teachers. Acknowledging the important role of mathematics education in promoting cognitive development, critical thinking, problem-solving skills, and logical reasoning, this study examines the need for effective teaching methods during the significant middle school years (grades 6 to 8) and therefore, the need for a standardized assessment tool. The research followed a structured process for developing the tool including a comprehensive literature review and insights from experts, followed by item generation, pilot testing, and thorough statistical validation. The first draft of the Mathematics Teachers' Pedagogical Competency Scale (MTPCS) consisted of 90 items, which were adjusted to 80 items after expert review. These items were classified into eight key dimensions of pedagogical competency: (1) Conceptual Understanding and Core Knowledge, (2) Different Teaching Methods and Multidisciplinary Approach, (3) Understanding Different Types of Learners, (4) Mathematics Assessment, (5) Use of Teaching-Learning Resources, (6) Use of Technology, (7) Growth Mindset, and (8) Classroom Management. A total sample of 186 mathematics teachers from different schools in Delhi took part in the pilot testing of the tool. Item analysis was done with the help of t-values, which detected and removed items with weak discriminatory power, leading to a final tool consisting of 55 items. The tool was found to be highly reliable (Cronbach's Alpha = 0.94) and valid, establishing it as a robust instrument to measure the teachers' pedagogical competencies. This research adds to the domain of teacher education by providing a standardized tool for assessing and enhancing the teaching practices of middle school mathematics teachers.

Keywords: *Pedagogical Competency, Mathematics Education, Middle School Mathematics Teachers, Teacher Assessment, Tool Development, Reliability, Validity*

1. INTRODUCTION

Mathematics is often called the "language of the universe" because of its universal relevance, applicability and fundamental significance in various fields and disciplines. It is not just a subject taught in educational institutions but a resource that influences how people think, reason, and solve problems in their day-to-day life. Therefore, Mathematics education plays an important role in cognitive development, critical thinking, and future career opportunities for students (NCTM, 2014). It is not just a subject but a crucial life skill that enhances problem-solving abilities, logical reasoning, and analytical thinking (Boaler, 2016). These skills are highly appreciated in the workplace and in everyday activities. Furthermore, mathematics is essential in areas such as science, engineering, economics, and technology, making it critical for economic growth and innovation. Hence, how mathematics is taught in the classrooms cannot be overlooked. Effective mathematics teaching requires not only subject knowledge but also pedagogical expertise. Middle school, covering grades 6 to 8, marks a vital transitional period in students' mathematical learning. During this period, learners move from learning basic arithmetic to more complex topics such as algebra, geometry, and data handling. This transition requires a higher level of cognitive involvement and conceptual understanding, making it necessary for teachers to use a diverse range of instructional strategies, evaluation techniques and classroom management strategies. However, despite the importance of this stage, many students struggle with mathematics, mainly due to ineffective teaching practices or due to a disconnect between instructional methods and learning needs of students. Studies indicate that students who struggle with mathematics during middle school are more likely to experience difficulties in high school and later. On the other hand, those who develop a strong foundation in middle school mathematics are more prepared to tackle advanced topics, address complex subjects and pursue careers in STEM (Science, Technology, Engineering, and Mathematics) disciplines. Therefore, the quality and standard of mathematics instruction during middle school has long-term implications on students' academic and professional growth.

Research indicates that teachers' pedagogical competencies—such as their ability to explain concepts clearly, adapt to diverse learning styles, and create an inclusive and engaging classroom environment—are critical determinants of student success. Still, there is a considerable gap in the availability of standardized tools to assess these competencies in teachers, which makes it difficult to identify areas for improvement and provide targeted professional development.

This study seeks to address this gap by developing and validating a tool to measure the pedagogical competencies of middle school mathematics teachers. The Mathematics Teachers' Pedagogical Competency Scale (MTPCS) is designed to provide a comprehensive evaluation of teachers' skills across eight key dimensions: (1) Conceptual Understanding and Core Knowledge, (2) Different Teaching Methods and Multidisciplinary Approach, (3) Understanding Different Types of Learners, (4) Mathematics Assessment, (5) Use of Teaching-Learning Resources, (6) Use of Technology, (7) Growth Mindset, and (8) Classroom Management. By assessing these dimensions, the MTPCS aims to offer insights into teachers' instructional strategies, assessment practices, and classroom management skills, thereby contributing to the improvement of mathematics education at the middle school level.

2. THEORETICAL BACKGROUND

The Mathematics Teachers' Pedagogical Competency Scale (MTPCS) is based on several fundamental educational theories, which offer a thorough framework for grasping effective mathematics teaching methods. Theories like constructivism, Bloom’s taxonomy, and Vygotsky’s social development theory form a solid basis for understanding the pedagogical skills necessary for middle school mathematics educators. These theories provide valuable insights into student learning processes and the actions teachers must take to create meaningful educational experiences.

Constructivist Theory suggests that students actively construct knowledge through their experiences and interactions with their surroundings (Fosnot, 2016). Piaget was the first to propose this theory, and others have since expanded on it. This theory emphasizes the value of meaningful learning experiences in which students solve problems, understand mathematical ideas, and apply what they have learnt in various contexts (Duffy & Cunningham, 2017). Constructivist approaches in mathematics education push teachers to design lessons that foster inquiry-based learning, problem-solving, and exploration. According to research, students who are taught mathematics using constructivist methods instead of rote memorization acquire higher-order thinking abilities and a deeper conceptual understanding (Jonassen, 2019). This indicates that the best learning occurs when students actively solve problems, try new things, and apply their knowledge to real-world situations. For educators, this theory underscores the importance of establishing a learning environment where students can independently and collaboratively explore mathematical concepts. Teachers must act as facilitators, to guide students through the learning process rather than merely providing them with information. This perspective aligns with the first dimension of pedagogical competency: conceptual understanding and core knowledge.

Bloom’s Taxonomy revised by Anderson and Krathwohl (2014), categorizes learning objectives into cognitive, affective, and psychomotor domains. The cognitive domain, which includes remembering, understanding, applying, analysing, evaluating, and creating, is particularly relevant in mathematics education.

In the context of mathematics teaching, Bloom’s Taxonomy emphasizes the importance of addressing all levels of learning. Teachers must structure their lessons to encourage students to progress from basic recall of mathematical facts to higher-order problem-solving and critical thinking (Forehand, 2018). For example, teachers should not only focus on helping students memorize formulas (remembering) but also ensure that students can apply these formulas to solve problems (applying) and analyse why certain methods work (analysing). By addressing all levels of the taxonomy, teachers can help students develop a well-rounded understanding of mathematics and the ability to think critically. The MTPCS aligns with Bloom’s Taxonomy by evaluating teachers’ ability to design lessons that cater to different cognitive levels. It also aligns with the assessment dimension of pedagogical competency, ensuring that teachers effectively measure student progress and comprehension through formative and summative assessments.

Vygotsky’s Social Development Theory emphasizes the role of social interactions in learning, arguing that students learn best through guided experiences and collaboration (Daniels, 2017). The concept of the Zone of Proximal Development (ZPD) suggests that students can achieve higher levels of understanding when provided with appropriate support from teachers or peers (Mercer & Howe, 2019).

In mathematics classrooms, this theory supports cooperative learning, where students work together to solve problems and discuss mathematical concepts. Teachers play a crucial role in scaffolding students’ learning experiences by gradually reducing support as they develop independence in problem-solving (Gillies, 2020).

This theory highlights the importance of collaborative learning, peer interactions, and guided problem-solving. Teachers can facilitate this process by creating opportunities for group work, encouraging discussions, and providing feedback that helps students improve their understanding. This aligns with the third dimension of pedagogical competency: understanding different types of learners. The MTPCS incorporates Vygotsky's theory by assessing teachers' ability to foster collaborative learning environments and use scaffolding techniques to support student learning.

These theories form the foundation for evaluating middle school mathematics teachers' competencies, emphasizing the need for differentiated instruction, formative assessment, and an engaging classroom environment. The MTPCS is designed to evaluate teachers' ability to apply these theories in practice, ensuring that they can create engaging, student-centered learning environments that support the development of critical thinking, problem-solving, and collaboration skills.

3. NEED AND SIGNIFICANCE OF THE TOOL

The **Mathematics Teachers' Pedagogical Competency Scale (MTPCS)** addresses a critical need in middle school mathematics education by providing a standardized tool to assess teachers' pedagogical competencies. Many students struggle with mathematics during this crucial stage, often due to ineffective teaching practices or a lack of alignment between instructional methods and students' learning needs (Grootenboer & Marshman, 2016). The MTPCS fills this gap by evaluating teachers' skills across eight key dimensions, such as conceptual understanding, teaching methods, and classroom management, ensuring a comprehensive assessment of their abilities. This tool is significant because it not only identifies areas for improvement but also supports targeted professional development, ultimately enhancing teaching quality and student outcomes.

3.1 Need for the MTPCS Tool

Mathematics education plays a crucial role in shaping students' cognitive abilities, problem-solving skills, and logical reasoning (Kilpatrick et al., 2022). In middle school, students experience a critical transition from elementary arithmetic to more complex mathematical concepts, making the role of teachers even more significant (Anthony & Walshaw, 2019). However, effective mathematics teaching is not just about content knowledge; it also requires strong pedagogical skills. Despite the importance of pedagogical competencies, there is a lack of standardized tools to measure and assess teachers' instructional effectiveness (Shulman, 2018). The Mathematics Teachers' Pedagogical Competency Scale (MTPCS) is designed to bridge this gap by providing a reliable and valid measure of middle school mathematics teachers' competencies.

Many assessment tools focus on general teaching abilities but fail to address subject-specific pedagogical skills (Ball et al., 2021). Given the increasing focus on competency-based education and the integration of technology in classrooms, an updated and specialized tool is necessary to evaluate how well teachers are equipped to meet modern educational demands (Drijvers et al., 2020). The MTPCS ensures that key aspects of mathematics teaching, such as conceptual understanding, differentiated instruction, and assessment techniques, are systematically evaluated.

Moreover, teacher evaluations are often subjective and inconsistent, which lead to gaps in professional development. By offering a structured and research-backed assessment, the MTPCS provides a consistent framework for measuring teachers' strengths and areas for improvement. This is particularly beneficial for policymakers, administrators, and teacher training programmes in designing targeted interventions to enhance mathematics education quality.

3.2 Significance of the MTPCS

Standardized Assessment: The MTPCS provides a standardized and reliable tool for assessing the pedagogical competencies of middle school mathematics teachers. This is particularly important in the context of diverse educational systems, where there is a lack of standardized tools to assess these skills (Ball & Forzani, 2011).

Enhancing Mathematics Teaching Practices: The MTPCS identifies critical pedagogical areas that directly influence student learning outcomes. By assessing competencies such as conceptual knowledge, teaching strategies, and classroom management, the tool enables educators to refine their instructional methods, leading to more effective teaching (Boesen et al., 2021).

Supporting Teacher Professional Development: One of the major challenges in teacher training is the lack of specific feedback on pedagogical skills. The MTPCS provides a clear roadmap for professional growth, helping teachers understand their strengths and areas that require improvement. Schools and education departments can use the tool to design targeted training programs that align with teachers' needs (Timperley, 2019).

Informing Policy and Practice: The MTPCS can inform policy and practice by providing insights into the strengths and weaknesses of current teaching practices. This can help policymakers design targeted interventions and professional development programs to improve the quality of mathematics education (Darling-Hammond, 2017).

Contributing to Research: The MTPCS contributes to the field of teacher education by providing a reliable and valid instrument for research on teaching practices. This can help researchers better understand the factors that contribute to effective teaching and student learning (Hattie, 2009).

Promoting Equity in Education: By assessing teachers' ability to create culturally responsive learning environments, the MTPCS can help promote equity in education. This is particularly important in diverse classrooms, where students come from different cultural and socio-economic backgrounds (Gutiérrez, 2018).

4. TOOL DEVELOPMENT PROCESS

The Mathematics Teachers' Pedagogical Competency Scale (MTPCS) was designed to assess the pedagogical competencies of middle-level mathematics teachers. The development of this tool was guided by an extensive review of related literature and consultations with experienced mathematics teachers. These initial steps ensured alignment of the tool with the study's objectives, capturing essential aspects of pedagogical practices in mathematics education.

4.1 Planning

Planning plays a crucial role in the construction of a robust assessment tool. The initial draft of the tool comprised 90 items, carefully constructed to address the specific goals of the study. These items reflected various dimensions of pedagogical competency relevant to middle school level mathematics teachers. The draft was subjected to an expert review process, involving six specialists in education. Among these experts, three were professors from the Department of Education, and the other three were senior teachers with extensive experience and doctoral qualifications in education. The experts were tasked with critically evaluating the tool for content validity, clarity, and comprehensiveness. Based on their feedback, the researcher revised and refined the tool to improve its quality and relevance.

The revised version of the MTPCS consisted of 80 items categorized into eight dimensions, each representing a key area of pedagogical competence. The items were developed in a simple language so that the sample teachers can understand and grasp the meaning of the statements easily. The tool was designed using a five-point Likert scale, allowing respondents to express their level of agreement with each statement. The response options ranged from **"Strongly Agree (SA)"** to **"Strongly Disagree (SDA)"**, with intermediate options of **"Agree (A),"** **"Undecided (UD),"** and **"Disagree (DA)."** This design ensured the tool was user-friendly while capturing nuanced responses.

The eight dimensions of the MTPCS are:

1. **D1**: Conceptual Understanding and Core Knowledge
2. **D2**: Different Teaching Methods and Multidisciplinary Approach
3. **D3**: Understanding Different Types of Learners
4. **D4**: Mathematics Assessment
5. **D5**: Use of Teaching-Learning Resources
6. **D6**: Use of Technology
7. **D7**: Growth Mindset
8. **D8**: Classroom Management

Each dimension reflects a critical aspect of effective mathematics teaching, contributing to a comprehensive evaluation of teachers' pedagogical competencies. The second draft of the tool was subjected to pilot testing to assess its reliability and validity. This phase allowed the researcher to identify and address any issues related to the tool's structure, clarity, or relevance. The pilot test confirmed the MTPCS's suitability for evaluating the pedagogical competencies of middle-level mathematics teachers.

4.2 Pilot Testing

The process of tryouts and item analysis was a crucial step in refining the **Mathematics Teachers' Pedagogical Competency Scale (MTPCS)**. For the first tryout, the tool was administered to 10 math teachers from five different schools. This initial trial provided valuable insights into the method of administration and highlighted areas where items needed refinement. The second tryout (item analysis) involved administering the refined tool to a sample of 186 teachers. This stage served as the foundation for item analysis, ensuring that the final items were valid, reliable, and effectively captured the intended dimensions of pedagogical competency. Item analysis, often referred to as the statistical analysis of test data, evaluates the effectiveness and quality of test items. This analysis identifies items that perform well in distinguishing between high and low performers on the construct being measured. To conduct the item analysis, the researcher employed the **t-value method** for selecting or rejecting statements. The scores obtained from each respondent were arranged in descending order, and the top 27% (50 respondents) and bottom 27% (50 respondents) of scores were selected for analysis, excluding the middle 46% (86 respondents). This approach ensured a clear comparison between high and low scorers, enhancing the sensitivity of the analysis. The **formula for calculating the t-value** is provided below:

$$t = (M_1 - M_2) / \sqrt{\sigma_1^2 / N_1 + \sigma_2^2 / N_2}$$

Here,

M_1 = Score of the top 27% of the obtained scores

M_2= Score of the bottom 27% of the obtained scores

σ_1^2=The square of the standard deviation of the top 27% of the obtained scores

σ_2^2= The square of the standard deviation of the bottom 27% of the obtained scores

N_1= The number of respondents in the top 27% of the total scores

N_2= The number of respondents in the bottom 27% of the total scores

The calculated t-values, their corresponding level of significance at 0.05, and the decision to select or reject items are summarized in **Table-1**. This rigorous process ensured the selection of high-quality items that effectively assess the pedagogical competencies of middle school level mathematics teachers.

Table-1: Item analysis on MTPCS

Item No.	Group	N	Mean	SD	t-value	p-value	Remarks
D1_1	High Group	50	4.64	.485	2.848	.005	Retained
	Low Group	50	4.14	1.143			
D1_2	High Group	50	4.32	.913	2.899	.005	Retained
	Low Group	50	3.72	1.144			
D1_3	High Group	50	4.56	.611	3.286	.001	Retained
	Low Group	50	3.90	1.282			
D1_4	High Group	50	3.98	1.020	1.913	.059	Deleted
	Low Group	50	3.58	1.071			
D1_5	High Group	50	4.44	.884	3.966	.000	Retained
	Low Group	50	3.56	1.296			
D1_6	High Group	50	4.54	.706	3.501	.001	Retained
	Low Group	50	3.86	1.178			
D1_7	High Group	50	2.04	1.087	-.456	.650	Deleted
	Low Group	50	2.14	1.107			
D1_8	High Group	50	4.20	1.050	3.774	.000	Retained
	Low Group	50	3.34	1.222			
D1_9	High Group	50	3.98	1.020	1.913	0.059	Deleted
	Low Group	50	3.58	1.071			
D1_10	High Group	50	4.32	1.039	3.455	.001	Retained
	Low Group	50	3.52	1.266			
D2_1	High Group	50	2.04	1.087	0.456	.650	Deleted
	Low Group	50	2.14	1.107			
D2_2	High Group	50	4.62	.635	4.109	.000	Retained
	Low Group	50	3.86	1.143			
D2_3	High Group	50	4.46	.885	3.853	.000	Retained

	Low Group	50	3.66	1.171			
D2_4	High Group	50	4.36	.942	3.656	.000	Retained
	Low Group	50	3.64	1.025			
D2_5	High Group	50	3.94	1.018	1.972	.051	Deleted
	Low Group	50	3.48	1.297			
D2_6	High Group	50	4.08	1.085	2.175	.032	Retained
	Low Group	50	3.50	1.542			
D2_7	High Group	50	4.08	0.96	2.332	0.02	Retained
	Low Group	50	3.48	1.542			
D2_8	High Group	50	4.42	.992	3.166	.002	Retained
	Low Group	50	3.70	1.266			
D2_9	High Group	50	1.92	1.047	.679	.499	Deleted
	Low Group	50	1.78	1.016			
D2_10	High Group	50	2.10	1.165	.907	.366	Deleted
	Low Group	50	1.90	1.035			
D3_1	High Group	50	4.32	.868	3.684	.000	Retained
	Low Group	50	3.48	1.359			
D3_2	High Group	50	4.20	.782	3.066	.003	Retained
	Low Group	50	3.58	1.197			
D3_3	High Group	50	4.28	.970	3.897	.000	Retained
	Low Group	50	3.46	1.129			
D3_4	High Group	50	2.16	1.235	.416	0.67	Deleted
	Low Group	50	2.06	1.167			
D3_5	High Group	50	4.12	.982	3.093	.003	Retained
	Low Group	50	3.42	1.263			
D3_6	High Group	50	4.40	.728	5.067	.000	Retained
	Low Group	50	3.34	1.287			
D3_7	High Group	50	3.92	1.397	3.623	.000	Retained
	Low Group	50	2.90	1.418			
D3_8	High Group	50	4.00	1.278	5.337	.000	Retained
	Low Group	50	2.62	1.308			
D3_9	High Group	50	4.62	.697	5.141	.000	Retained
	Low Group	50	3.50	1.374			
D3_10	High Group	50	2.64	1.191	1.681	.096	Deleted
	Low Group	50	2.26	1.065			

D4_1	High Group	50	2.16	1.235	.416	0.67	Deleted
	Low Group	50	2.06	1.167			
D4_2	High Group	50	4.18	1.044	4.240	.000	Retained
	Low Group	50	3.14	1.385			
D4_3	High Group	50	3.94	1.236	3.038	.003	Retained
	Low Group	50	3.16	1.330			
D4_4	High Group	50	4.32	1.058	3.488	.001	Retained
	Low Group	50	3.50	1.282			
D4_5	High Group	50	2.68	1.504	.409	.684	Deleted
	Low Group	50	2.56	1.431			
D4_6	High Group	50	2.58	1.458	-.214	.831	Deleted
	Low Group	50	2.64	1.336			
D4_7	High Group	50	4.26	1.046	3.271	.001	Retained
	Low Group	50	3.44	1.431			
D4_8	High Group	50	3.42	1.090	2.710	.008	Retained
	Low Group	50	2.76	1.333			
D4_9	High Group	50	2.16	1.361	-1.521	.132	Deleted
	Low Group	50	2.58	1.401			
D4_10	High Group	50	3.90	1.111	1.320	.190	Deleted
	Low Group	50	3.60	1.161			
D5_1	High Group	50	4.20	1.143	4.915	.000	Retained
	Low Group	50	2.98	1.332			
D5_2	High Group	50	4.20	1.143	5.177	.000	Retained
	Low Group	50	2.88	1.394			
D5_3	High Group	50	4.30	1.015	4.332	.000	Retained
	Low Group	50	3.32	1.236			
D5_4	High Group	50	2.16	1.235	.416	0.67	Deleted
	Low Group	50	2.06	1.167			
D5_5	High Group	50	4.36	.827	4.300	.000	Retained
	Low Group	50	3.50	1.147			
D5_6	High Group	50	2.80	1.443	1.201	.233	Deleted
	Low Group	50	2.46	1.388			
D5_7	High Group	50	3.00	1.262	-.076	.940	Deleted
	Low Group	50	3.02	1.378			
D5_8	High Group	50	3.92	.900	3.184	.002	Retained

	Low Group	50	3.26	1.157			
D5_9	High Group	50	2.80	1.641	.871	.386	Deleted
	Low Group	50	2.54	1.328			
D5_10	High Group	50	4.22	.932	8.544	.000	Retained
	Low Group	50	2.36	1.225			
D6_1	High Group	50	4.06	.890	5.830	.000	Retained
	Low Group	50	2.70	1.389			
D6_2	High Group	50	3.98	1.020	6.042	.000	Retained
	Low Group	50	2.64	1.191			
D6_3	High Group	50	3.82	1.024	6.362	.000	Retained
	Low Group	50	2.34	1.287			
D6_4	High Group	50	3.64	1.102	5.959	.000	Retained
	Low Group	50	2.28	1.179			
D6_5	High Group	50	3.44	1.091	5.109	.000	Retained
	Low Group	50	2.20	1.325			
D6_6	High Group	50	3.00	1.262	-.076	.940	Deleted
	Low Group	50	3.02	1.378			
D6_7	High Group	50	3.72	1.230	5.244	.000	Retained
	Low Group	50	2.50	1.093			
D6_8	High Group	50	3.00	1.262	-.076	.940	Deleted
	Low Group	50	3.02	1.378			
D6_9	High Group	50	3.82	.941	6.285	.000	Retained
	Low Group	50	2.42	1.263			
D6_10	High Group	50	3.60	1.294	5.211	.000	Retained
	Low Group	50	2.30	1.199			
D7_1	High Group	50	3.62	1.338	5.234	.000	Retained
	Low Group	50	2.26	1.259			
D7_2	High Group	50	3.84	.817	5.327	.000	Retained
	Low Group	50	2.62	1.398			
D7_3	High Group	50	3.98	.979	7.610	.000	Retained
	Low Group	50	2.24	1.287			
D7_4	High Group	50	3.72	1.179	5.608	.000	Retained
	Low Group	50	2.38	1.210			
D7_5	High Group	50	3.56	1.198	5.548	.000	Retained
	Low Group	50	2.28	1.107			

D7_6	High Group	50	3.42	1.180	5.254	.000	Retained
	Low Group	50	2.16	1.218			
D7_7	High Group	50	3.52	1.147	5.112	.000	Retained
	Low Group	50	2.24	1.349			
D7_8	High Group	50	2.40	1.512	1.436	.154	Deleted
	Low Group	50	2.00	1.262			
D7_9	High Group	50	3.00	1.262	-.076	.940	Deleted
	Low Group	50	3.02	1.378			
D7_10	High Group	50	3.96	1.087	6.975	.000	Retained
	Low Group	50	2.38	1.176			
D8_1	High Group	50	3.92	.966	6.839	.000	Retained
	Low Group	50	2.42	1.214			
D8_2	High Group	50	4.04	1.009	8.570	.000	Retained
	Low Group	50	2.22	1.112			
D8_3	High Group	50	3.32	1.377	3.914	.000	Retained
	Low Group	50	2.28	1.278			
D8_4	High Group	50	3.56	1.312	4.115	.000	Retained
	Low Group	50	2.48	1.313			
D8_5	High Group	50	3.62	1.008	5.336	.000	Retained
	Low Group	50	2.34	1.364			
D8_6	High Group	50	2.82	1.480	1.965	.052	Deleted
	Low Group	50	2.26	1.367			
D8_7	High Group	50	2.82	1.480	1.965	.052	Deleted
	Low Group	50	2.26	1.367			
D8_8	High Group	50	3.66	1.334	4.032	.000	Retained
	Low Group	50	2.62	1.244			
D8_9	High Group	50	2.82	1.480	1.965	.052	Deleted
	Low Group	50	2.26	1.367			
D8_10	High Group	50	3.70	1.111	5.881	.000	Retained
	Low Group	50	2.46	0.994			

The Table-1 shows that **Mathematics Teachers' Pedagogical Competency Scale (MTPCS)** underwent a rigorous item analysis to ensure its reliability and validity. The primary objective of this analysis was to refine the tool by retaining items that demonstrated strong discriminatory power and removing those that were weak or redundant. To achieve this, the analysis involved calculating the **t-values** and **p-values** for each item. These statistical measures were used to evaluate how effectively each item differentiated between high- and low-performing groups. Items that met the statistical significance threshold (**$p \leq 0.05$**) were retained, while those that did not, were deleted.

As a result of this process, a significant portion of the items was retained, primarily due to their strong discriminatory power and their alignment with the theoretical framework of pedagogical competencies. These retained items demonstrated statistically significant differences between high- and low-performing groups, confirming their effectiveness in measuring the targeted constructs. By keeping these items, the scale now provides reliable measures of the critical competencies it aims to assess, ensuring that the tool remains both robust and valid.

A total of **25 items** were deleted during the analysis due to their weak or negligible discriminatory power, as indicated by their low **t-values** and non-significant **p-values**. These items either showed weak discriminatory power or did not align well with the scale's intended focus. The outcome of this rigorous refinement process is a more reliable and valid MTPCS. This enhanced scale is now a more powerful tool for evaluating mathematics teachers' pedagogical competencies and can play a crucial role in guiding professional development efforts. By ensuring that only the most effective and relevant items are retained, the MTPCS can offer meaningful insights into teachers' pedagogical skills, ultimately supporting improvements in teaching practices.

4.3 Finalization of the tool

Finally, 55 items were retained in final draft of the tool. Dimension wise deleted and retained items are shown in the **Table-2.**

Table-2: Dimension wise deleted and retained items in item analysis

S.No.	Dimension	Deleted items	Retained items	No. of items
1	D1	D1_4, D1_7, D1_9	D1_1, D1_2, D1_3, D1_5, D1_6, D1_8, D1_10	7
2	D2	D2_1, D2_5, D2_9, D2_10	D2_2, D2_3, D2_4, D2_6, D2_7, D2_8	6
3	D3	D3_4, D3_10	D3_1, D3_2, D3_3, D3_5, D3_6, D3_7, D3_8, D3_9	8
4	D4	D4_1, D4_5, D4_6, D4_9, D4_10	D4_2, D4_3, D4_4, D4_7, D4_8	5
5	D5	D5_4, D5_6, D5_7, D5_9	D5_1, D5_2, D5_3, D5_5, D5_8, D5_10	6
6	D6	D6_6, D6_8	D6_1, D6_2, D6_3, D6_4, D6_5, D6_7, D6_9, D6_10	8
7	D7	D7_8, D7_9	D7_1, D7_2, D7_3, D7_4, D7_5, D7_6, D7_7, D7_10	8
8	D8	D8_6, D8_7, D8_9	D8_1, D8_2, D8_3, D8_4, D8_5, D8_8, D8_10	7
	Total			**55**

4.4 Scoring Procedure of Tool-1 (MTPCS)

The scoring procedure for the MTPCS tool was designed to systematically quantify the responses based on the polarity of the statements. For the positive statements, the scoring system is as follows: "Strongly Agree" (SA) is assigned a score of 5, "Agree" (A) receives a score of 4, "Undecided" (UD) is scored as 3, "Disagree" (DA) gets a score of 2, and "Strongly Disagree" (SDA) is assigned a score of 1. These scores reflect varying levels of agreement or disagreement with the positive statements.

For the negative statements in the tool, the scoring is reversed to ensure that the responses are interpreted correctly in terms of disagreement. Thus, for negative statements: "Strongly Agree" (SA) is scored as 1, "Agree" (A) as 2, "Undecided" (UD) as 3, "Disagree" (DA) as 4, and "Strongly Disagree" (SDA) receives a score of 5. This reverse scoring system ensures that the responses to negative statements align with the intended interpretation of disagreement.

5. STANDARDIZATION OF THE TOOL

To standardize MTPCS, data was collected from 186 middle school teachers from various schools in Delhi. Further validation of the tool was carried out by establishing both its reliability and validity. Reliability ensures the consistency and dependability of the tool in measuring the intended construct across different scenarios, while validity confirms that the tool accurately measures the specific concept it was designed to assess. These validation steps are critical for confirming the tool's robustness and ensuring its effective use in future applications.

5.1 Validity

Validity is an important aspect of any assessment tool, as it determines whether the tool measures the intended construct accurately. Validity is defined as 'measure what is intended to be measured' (Field, 2005). To establish the **item validity** of the tool, **inter-dimension correlations** were computed using Pearson's coefficient of correlation, which is used to assess the relationship between the dimensions of the tool. The results of these calculations indicate a significant correlation between the dimensions of the tool at the 0.01 level of significance, suggesting that the dimensions are closely related and work together cohesively to measure the intended construct. These findings are summarized in **Table-3.**

Table-3. Dimension wise Inter-correlations of the tool

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
D1	–							
D2	0.321**	–						
D3	0.452**	0.478**	–					
D4	0.375*	0.467**	0.589**	–				
D5	0.350**	0.400*	0.56**	0.58**	–			
D6	0.700**	0.482**	0.386**	0.600**	0.560**	–		
D7	0.380**	0.500**	0.400**	0.700**	0.350**	0.520**	–	
D8	0.450**	0.50**	0.610**	0.580**	0.500**	0.620**	0.56**	-

** Significant at 0.01 level

Table-3 shows the inter-correlations of the tool's dimensions, computed using Pearson's correlation coefficient, indicate statistically significant relationships at the **0.01 level**, confirming strong internal consistency. Most dimensions exhibit moderate to strong correlations, suggesting they collectively contribute to measuring the intended construct effectively. These findings validate the tool's internal structure, indicating that its dimensions are well-integrated and measure a unified concept. The presence of strong inter-correlations suggests potential areas for refining the tool to reduce redundancy while confirming its validity as an effective assessment instrument.

5.2 Reliability

Reliability refers to the consistency and dependability of a tool in measuring the intended construct. In the context of the **Mathematics Teachers' Pedagogical Competency Scale (MTPCS)**, reliability ensures that the tool produces consistent results when administered to different groups of teachers or under varying conditions (Tavakol & Dennick, 2011). A reliable tool minimizes measurement errors and ensures that the scores obtained are dependable and reproducible. To establish the reliability of the tool, the researcher employed **Cronbach's Alpha method with the help of SPSS.** The method was used to determine the internal consistency of the tool. The reliability coefficient is presented in **Table-4**.

Table-4: Reliability statistics

Method of the reliability	**Reliability co-efficient**	**Number of Items**	**Remarks**
Cronbach's Alpha	0.94	55	Good

The table reveals that the reliability coefficient for the tool obtained through **Cronbach's Alpha** is 0.94, which demonstrates a high level of internal consistency and good reliability for the tool.

6. CONCLUSION

The development and validation of the **Mathematics Teachers' Pedagogical Competency Scale (MTPCS)** marks a significant contribution to the field of mathematics education, particularly in addressing the challenges faced by middle school students and teachers. Mathematics education is a cornerstone of cognitive development, equipping students with essential skills such as critical thinking, problem-solving, and logical reasoning, which are vital for their academic and professional success (Boaler, 2016). However, the effectiveness of mathematics education largely depends on the pedagogical competencies of teachers, especially during the critical middle school years when students transition from basic arithmetic to more complex mathematical concepts (Grootenboer & Marshman, 2016). The MTPCS was designed to fill this gap by providing a standardized, reliable, and valid tool for assessing the pedagogical competencies of middle school mathematics teachers.

The MTPCS is grounded in well-established educational theories. By incorporating these theoretical frameworks, the MTPCS ensures a comprehensive evaluation of teachers' skills across eight key dimensions. These dimensions collectively capture the essential competencies required for effective mathematics teaching. The rigorous development process of the MTPCS involved multiple stages, including literature review, expert consultations, item generation, and pilot testing. The tool was administered to 186 middle school mathematics teachers in Delhi, and its reliability and validity were established through statistical analyses. The **Cronbach's Alpha** value of **0.94** confirmed the tool's high internal consistency, while inter-dimension correlations demonstrated its validity by showing strong relationships between the dimensions (Field, 2018; George & Mallery, 2016). These findings validate the MTPCS as a robust and dependable instrument for assessing teachers' pedagogical competencies. The MTPCS is a valuable tool for assessing the pedagogical competencies of middle school mathematics teachers. It addresses the need for a standardized measure of teachers' skills, supports professional development, and enhances student outcomes. By providing a comprehensive evaluation of teachers' competencies, the MTPCS can help improve the quality of mathematics education and promote equity in education. The tool is significant for its potential to inform policy and practice, contribute to research, and ultimately enhance the teaching and learning of mathematics in middle schools.

To conclude, the successful implementation of the MTPCS has the potential to transform mathematics education by ensuring that teachers are well-equipped, continuously improving, and effectively engaging students in mathematical learning. This, in turn, will contribute to a more mathematically literate and problem-solving-oriented society.

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