International Journal of Creative and Open Research in Engineering and Management
ISSN: **3108-1754 (Online)**
Volume 02 Issue 05 May-2026 | Impact Factor: 3.5

Developmental Trajectories, Equity Gaps, and Normative Standards for Micro Thinking Sub-skills in Middle Stage School Students: Evidence from the MTST Standardization Study in Gujarat, India

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Funding Acknowledgment:

This research is a part of the Collaborative Research Programme in Educational Assessment and Psychometrics, sponsored by the **Children's Research University**, **Gandhinagar, Gujarat**, India for the year 2024-26 and funded by the University. The authors would be delighted by the support of the Children's Research University, including provision of institutional support, research infrastructure, open publication and dissemination resources throughout the project. The funding body was not involved in the design of the study, data collection, data analysis, data interpretation, nor the writing of the manuscript. The opinions expressed are those of the authors and do not necessarily reflect the opinions of the author(s) as a whole or the opinions of the publisher.

How to Cite this Article:
Parmar, M. & Desai, P. (2026). Developmental Trajectories, Equity Gaps, and Normative Standards for Micro Thinking Sub-skills in Middle Stage School Students: Evidence from the MTST Standardization Study in Gujarat, India. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(05).
https://doi.org/10.55041/ijcope.v2i5.674

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https://doi.org/ 10.55041/ijcope.v2i5.674

ABSTRACT

Background: Knowledge and understanding of the evolution of discrete micro thinking sub-skills in middle school grades and their differences in school type, medium of instruction and gender are crucial for evidence-based educational policy and targeted classroom interventions. The present paper reports substantive findings on sub-skill developmental trajectories, equity gaps and normative standards, which is a distinct and independent empirical contribution from the Micro Thinking Skills Test (MTST), that was psychometrically standardized on a sample of N = 1,200 Grade 6-8 students in Gujarat.

Objectives: Knowledge and understanding of the evolution of discrete micro thinking sub-skills in middle school grades and their differences in school type, medium of instruction and gender are crucial for evidence-based educational policy and targeted classroom interventions. The present paper reports substantive findings on sub-skill developmental trajectories, equity gaps and normative standards, which is a distinct and independent empirical contribution from the Micro Thinking Skills Test (MTST), that was psychometrically standardized on a sample of N = 1,200 Grade 6-8 students in Gujarat.

Methods: One-way ANOVA, independent-samples t-tests, Tukey HSD post hoc comparisons and Cohen's d effect sizes were computed on the standardization sample (N = 1,200) - 400 x grade, 35 schools, 2 districts (Anand and Kheda) in Gujarat. Sub-skill profiles were analyzed at the sub-scale level in order to identify differential equity gaps by school type (Government, Grant-in-Aid, Private). Norms were generated for percentile, stanine, and T-score, for each grade individually.

Results: Mean total MTST scores increased significantly across grades (G6: M = 38.72; G7: M = 42.15; G8: M = 45.89; $F(2,1197) = 156.84$, $p < .001$, $\eta^2 = 0.208$). The sub-skill of Observation is always the strongest while Inference and Generalisation are the weakest at all grades, and have the largest grade-level gains. There was no difference between males and females ($p = .216$, $d = 0.10$). Significant school type differences ($F(2,1197) = 38.72$, $p < .001$, $\eta^2 = 0.061$) showed a five-point difference between private and government school students, with the most significant difference in the most cognitively demanding sub-skills. The percentile and stanine norms for each grade level give a practical interpretation to the data and are provided for practitioners.

Conclusions: Middle school is a sensitive age for development of inferential and abstract thinking. Systematic inequities in thinking skill development are found in the areas of Inference and Generalisation, pointing to differential quality of instructional environment and not ability differences and thus have direct implications for equity oriented policy under NEP 2020.

Keywords: Educational policy; Inference, Inference, School type difference, cognitive equity, thinking skill development, middle school education, Gujarat, Generalisation, NEP 2020, NEP 2020

1. INTRODUCTION

We know that the middle school years (Grades 6 through 8, ages 11-14) are a distinctively significant period of cognitive development. This is the period when children gain the ability to think abstractly, make inferences, and reason in a systematic way through hypothetical situations and make evaluative judgments, a stage grounded in Piaget's theory (1952). Resnick's (1987) seminal theory highlights this developmental period as the time when higher order thinking skills, if adequately developed, turn into broadly applicable capacities that support intellectual functioning throughout a lifetime.

The National Education Policy 2020 (Ministry of Education 2020) clearly calls for competency-based assessment at the middle school level, thereby making the measurement of thinking skills a national priority in education. However, the empirical evidence of the development of specific micro thinking sub-skills at the Grades 6–8 level in the Indian context and the moderation of the development by structural variables like medium of instruction, school type, and gender is not very rich. Without such evidence the design of targeted instructional interventions and development of an equity-focused policy is limited.

The present paper describes the substantive developmental and equity results of the MTST standardization study in a unique way, contributing to the empirical literature on cognitive development in Indian middle-school populations. In particular, it sets out to answer three inter-related questions: (1) What developmental pathways do the six micro thinking sub-skills trace over the six grade levels 6-8? (2) What are the differences between school-type and medium-of-instruction in thinking skill profiles and which sub skills are most affected? (3) What are the grade-level norms that can be used to inform evidence-based student and school-level educational decisions?

2. METHOD

2.1 Participants and Setting

The sample size of the standardization sample was N = 1200 students (Grade 6 = 400 students, Grade 7 = 400 students and Grade 8 = 400 students) selected from 35 schools using stratified multi-stage cluster sampling in Anand and Kheda districts, Gujarat, India. Stratification encompassed school type (Government: n = 399; Grant-in-Aid: n = 402; Private: n = 399), location (Urban: 40%; Semi-Urban: 30%; Rural: 30%), medium of instruction (Gujarati: n = 820; English: n = 380), and gender (Male: n = 612, 51%; Female: n = 588, 49%). Data was gathered from January-March 2025, using a highly standardized administration protocol, which was approved by the District Education Offices from both districts. Assent was obtained from all participants and parental/guardian informed consent was obtained before data collection. The institutional ethics board (ICSSR) guidelines were followed and ethics approval obtained.

2.2 Instrument

MTST is a 72 item, group administered, diagnostic tool with six sub scales of 12 items each: Observation, Comparison, Classification, Inference, Generalisation and Evaluation. All items scored 0 (incorrect/blank) or 1 (correct); sub-scale scores range 0-12; total scores range 0-72. The test lasts for 55 minutes. The instrument was designed over a nine-stage psychometric process (see companion paper) and had excellent overall reliability (Cronbach's $\alpha = 0.93$; test-retest $r = 0.87$) and good validity evidence (CVI = 0.87; six factor solution from EFA accounted for 60.07% of the variance; criterion validity $r = 0.61$ with teacher performance ratings).

2.3 Statistical Analysis

All scores were calculated using descriptive statistics (mean, standard deviation, 95% confidence intervals) stratified by grade, gender, school type and medium of instruction for the total MTST score as well as all six sub-scores. For all groups tests of normality were confirmed (Kolmogorov-Smirnov and Shapiro-Wilk tests; all $p > .05$), which allowed for the use of parametric analyses. The differences between grade level and school types were evaluated by one-way ANOVA and Tukey HSD post-hoc tests, while differences between gender and mediums were evaluated by independent-samples t-tests. For pairwise comparisons, Cohen's d was calculated and for ANOVA, partial eta-squared (η^2) was calculated. At the sub-scale level, sub-skill profiles by school type were analyzed to explore the absolute sub-scale M difference and percentage gap (gap as % of maximum sub-scale score = 12) in order to detect differential equity gaps. The distribution of the 400-student normative sample at each grade level was used to determine the percentile, stanine, and T score norms.

3. RESULTS

3.1 Developmental Trajectories by Sub-skill

The developmental trajectories by sub-skill are shown below. Below are shown the developmental trajectories by sub-skill. Means of the sub-skill scores are reported at the grade level (maximum possible per sub-skill = 12, maximum possible overall = 72) in Table 1. The strength of the sub-skills is clearly reflected across all three grades, where Observation is consistently the most powerful sub-skill, and Generalisation and Inference are consistently the least powerful sub-skills. This hierarchy applies at each grade level but the size of inter-grade steps is significantly different depending on the sub-skill. When looking at the difference in total means across the scale from Grade 6 to Grade 8, this increase is 7.17 points, which is a 10% increase.

Table 1. Mean MTST Sub-skill Scores by Grade Level

(N = 1,200; Maximum = 12 per Sub-skill, 72 Total)

Sub-skill	Grade 6 M (SD)	Grade 7 M (SD)	Grade 8 M (SD)	G6→G8 Δ
Observation	7.12 (1.89)	7.68 (1.74)	8.21 (1.62)	+1.09
Classification	6.88 (1.95)	7.41 (1.83)	8.02 (1.69)	+1.14
Comparison	6.54 (2.01)	7.23 (1.88)	7.89 (1.71)	+1.35
Evaluation	6.57 (2.08)	6.77 (1.98)	7.32 (1.88)	+0.75
Inference	5.93 (2.13)	6.72 (2.04)	7.44 (1.92)	+1.51
Generalisation	5.68 (2.24)	6.34 (2.11)	7.01 (1.98)	+1.33
Total MTST Score	**38.72 (7.43)**	**42.15 (7.19)**	**45.89 (6.88)**	**+7.17**

Note. M = mean; SD = standard deviation in parentheses; G6→G8 Δ = raw score increment from Grade 6 to Grade 8. All grade-to-grade increments significant at p < .001 for total MTST. Maximum sub-scale score = 12.

Interestingly, the largest increase in grade (2.51 points from grade 6 to grade 8; 12.6% of the maximum sub-scale score) occurred for Inference, followed closely by Comparison (+1.35) and Generalisation (+1.33). Among the other components, Evaluation has the smallest increment (+0.75) indicating that it may increase at a slower rate over this age span. This is a differential growth process in line with the theoretical perspective of Resnick (1987) who suggested that inferential reasoning is the most context-sensitive and developmentally dynamic higher-order thinking skill in the concrete-to-formal operational transition.

3.2 Gender Analysis

An independent-samples t-test comparing total MTST scores between male (n = 612, M = 41.88, SD = 7.92) and female (n = 588, M = 42.65, SD = 7.76) students yielded a non-significant result: t(1,198) = 1.24, p = .216, Cohen's d = 0.10 (negligible effect). The results of sub-scale analysis indicated also that there were no significant differences between the genders for each of the six sub-skills. The MTST is gender-nonselective — as in this population, the number of males with the MTST was equal to the number of females, and in line with the contemporary evidence that there is little difference between male and female reasoning abilities, when socioeconomic and cultural confounds are controlled for (Halpern, 2003).

3.3 School Type and Medium Equity Analysis

One-way ANOVA revealed a significant school type effect on total MTST scores: $F(2,1197) = 38.72$, $p < .001$, $\eta^2 = 0.061$ (medium effect). The medium of instruction comparison and Tukey HSD post-hoc comparisons are presented in Table 2. The mean score of the private school students (45.12) was significantly higher than the Government students (40.08) and Grant-in-Aid students (41.55) (p = .082).

Table 2. Pairwise Group Comparisons — School Type and Medium of Instruction (Effect Sizes)

Group Comparison	n (Group 1)	M (Group 1)	n (Group 2)	M (Group 2)	Cohen's d
Government vs. Grant-in-Aid	399	40.08	402	41.55	**0.18 (Small)**
Government vs. Private	399	40.08	399	45.12	**0.64 (Medium)**
Grant-in-Aid vs. Private	402	41.55	399	45.12	**0.46 (Medium)**
Male vs. Female (H_{01})	612	41.88	588	42.65	**0.10 (Negligible)**
Gujarati-med vs. English-med	820	41.20	380	44.85	**0.48 (Medium)**

Note. All Private vs. Government and Private vs. Grant-in-Aid comparisons significant at $p < .001$ (Tukey HSD). Government vs. Grant-in-Aid: $p = .082$ (not significant). Medium comparison: $t(1198) = 6.41$, $p < .001$. Cohen's d benchmarks: 0.20 = small, 0.50 = medium, 0.80 = large (Cohen, 1988). Medium effect partially confounded with school type (most private schools in the study region are English-medium).

3.4 Differential Sub-skill Equity Gaps by School Type

The sub-scale means by school type were also analyzed to see whether the school type equity gap is consistent over sub-skills or differentially distributed in specific cognitive domains. Table 3 shows the gap between the Private and Government results for each sub-skill in raw score units as well as a percentage of the maximum sub-scale score (12). Table 3. The Sub-skill Profile Comparison by School Type (Private vs. Government) Gap Analysis is an analysis of the differences between sub-skills present in these two types of schools.

Table 3. Sub-skill Profile Comparison by School Type — Private vs. Government Gap Analysis

Sub-skill	Govt M	GiA M	Private M	Pvt–Govt Gap	% Gap (of 12)
Observation	7.01	7.34	7.98	+0.97	8.1%
Classification	6.72	7.10	7.88	+1.16	9.7%
Comparison	6.40	6.89	7.67	+1.27	10.6%
Evaluation	6.35	6.61	7.22	+0.87	7.3%
Inference	5.55	6.12	7.11	+1.56	13.0%
Generalisation	5.20	5.84	6.88	+1.68	14.0%
Total MTST	**40.08**	**41.55**	**45.12**	**+5.04**	**7.0%**

Note. Govt = Government schools (n = 399); GiA = Grant-in-Aid schools (n = 402); Private schools (n = 399). % Gap = (Private M − Government M) / 12 × 100. Sub-skills ordered by Private-Government gap magnitude (ascending).

A striking differential pattern emerges with the Private-Government gap being smallest for Observation (0.97 points; 8.1% of maximum) and steadily increasing with the hierarchy, eventually reaching its maximum for Generalisation (1.68 points; 14.0%) and Inference (1.56 points; 13.0%). This inequitable distribution of the equity gap in the most cognitively demanding sub-skills (the abstract reasoning and principle formation sub-skills) strongly indicates that the gap is more the result of unequal quality of instructional environment than of differential ability levels. In the sample, the students in private schools are overrepresented in the skills that rely on pedagogical investments in abstract reasoning, structured discussion, and cognitively demanding classroom discourse: those are the skills that are most critical for their success.

3.5 Grade-Specific Normative Standards

Grade-level norms, along with suggestions for educational action, were established using the entire standardization sample (400 students per grade). Combined grade stanine norms are given in table 4. Grade-specific percentile and T score conversion tables are found in the MTST administration manual and are to be used to make precise individual interpretations; stanine norms are population-referenced categories with actionable educational guidance.

Table 4. MTST Stanine Norms: Combined Grades 6–8 with Educational Action Guidelines (N = 1,200)

St.	Category	Raw Score	% Sample	Educational Action
9	**Extremely High**	59–72	4%	Gifted referral; peer mentoring; advanced enrichment projects
8	**Very High**	54–58	7%	Enrichment and challenge activities; advanced thinking skill modules
7	**High**	49–53	12%	Continue current approach; optional extension in weaker sub-skills
6	**Above Average**	45–48	17%	Consolidate; targeted extension in relatively weaker sub-skills
5	**Average**	40–44	20%	Regular curriculum; no immediate intervention required
4	**Below Average**	35–39	17%	Targeted teacher support in 1–2 weakest sub-skills; structured practice
3	**Low**	30–34	12%	Structured thinking skill enrichment; monitoring; peer support groups
2	**Very Low**	25–29	7%	Intensive cognitive enrichment; school counsellor involvement
1	**Extremely Low**	< 25	4%	Specialist referral; Individual Educational Plan (IEP); full assessment

Note. St. = Stanine. Raw score ranges are for combined-grade norms; grade-specific percentile and T-score tables are available in the MTST Manual. GiA = Grant-in-Aid. Stanine percentile boundaries: 1 = P1–P3; 2 = P4–P11; 3 = P12–P23; 4 = P24–P39; 5 = P40–P59; 6 = P60–P76; 7 = P77–P88; 8 = P89–P95; 9 = P96–P99.

Grade-specific percentile norms indicated systematic increases as follows: at the median (P50) the grade 6 percentile scores were clustered around 39; at the median, the grade 7 percentile scores were clustered around 42; and at the median, the grade 8 percentile scores were clustered around 46, which indicates that grade-specific rather than combined percentile norms need to be used for individual diagnostic interpretations. It is best not to use combined sample norms for a student in Grade 8, because such a practice would systematically overestimate the student's position compared to other students in Grade 8.

4. DISCUSSION

4.1 Developmental Trajectories: Theory and Practice Implications

Observation occurs earlier and is able to attain higher mean performance across all grades, whereas abstract sub-skills (Inference, Generalisation) emerge later and develop more steeply across the middle school years, as supported by the developmental trajectory data and proposed by Piaget (1952). The fact that inference exhibited the greatest grade-to-grade increment (+1.51) is especially noteworthy, as it indicates that the days of middle school represent a critical window of opportunity for the development of inferential reasoning skills, and that targeted middle school interventions may provide disproportionately high returns. Perkins and Salomon's (1989) work on context-bound cognitive skills also helps to explain the Evaluation finding: the small grade increment (+0.75) may indicate the level of domain-specificity and context-sensitivity of evaluative judgment, which may take longer to develop during adolescence and involve the accumulation of a great deal of domain-specific knowledge. This implies that it might take longer to develop this sub-skill and have more content to be embedded within it than instruction for inference or generalisation.

4.2 The Equity Gap: Implications for Policy

These differences in concentration of the Private-Government school gap in the highest order sub-skills, “Inference” and “Generalisation”, are of great theoretical and policy significance. The finding that the gap is smallest in Observation (the perceptual, concrete sub-skill) and largest in Generalisation (the abstract, principle-forming sub-skill) confirms the opinion that the quality of the instructional environment has the greatest effect on the development of abstract reasoning (Vygotsky, 1978). The students from the government schools seem to be lacking in their baseline thinking ability; not so much that they don't have a capacity for thinking, as that they simply don't have access to the quality scaffolding of instruction needed to develop abstract reasoning capacities.

The outcomes of these findings have direct implications to the implementation of NEP 2020. The following should be emphasized in policy interventions to improve the government schools: (1) teacher professional development in generalisation and inference in the context of effective questioning strategies; (2) integration of the structured thinking skill enrichment curricula into the Gujarat GSEB middle school curriculum; (3) development and dissemination of classroom materials that provide scaffolding for generalisation and inference using meaningful and contextual tasks. The MTST's diagnostic sub-skill profile offers a useful method to track the equity gap over time and assess whether targeted interventions are closing that gap. Gender Equity is a strength of MTST.

4.3 Gender Equity: A Strength of the MTST

The lack of gender differences on all total MTST scores and sub-scores places the MTST in a neutral position with regard to gender and thus eliminates the danger of systematic discrimination against males or females in diagnostic profiling or in choosing intervention targets. The finding has practical implications in that schools can use MTST-generated profiles in instructional planning without worrying about the instrument's measurement bias by gender. It also adds to the broader empirical literature that indicates that gender differences in reasoning that have been documented in some western settings are not universal and are perhaps more to do with cultural and instructional factors than with differences in cognitive abilities (Halpern, 2003).

4.4 Practical Value of Grade-Specific Norms

The creation of grade specific percentile, stanine and T scores fills an important practical need. Based on the MTST scores of one student, practitioners can now compare the student's raw score to the other students in the same grade level in the region, which is a much more informative comparison than a comparison based on a combined or nationally derived sample. The psychometric information presented in the action guidelines (Table 4) is transformed into actionable educational response, thus allowing school counsellors and class teachers to make evidence-based decisions regarding enrichment, intervention and referral without having to utilize the expertise of a psychologist.

5. CONCLUSIONS AND RECOMMENDATIONS

The MTST standardization study has three major empirical findings that have educational implications. Micro thinking sub-skills follow a developmental sequence from Grade 6 to 8 and, identifying these as high priority targets for instructional investment, Observation matures first, followed by Inference and then Generalisation. Second, there was a persistent and large inequity between private and government school students in thinking skill development, with this inequity mostly concentrated in the more cognitively demanding sub-skills, and instructional environment quality was a likely explanation for this inequity, with targeted teacher professional development being the most likely policy lever. Third, percentile and stanine norms are available by grade, making the MTST a more useful research tool and a valuable diagnostic tool for making evidence-based, equity-driven decisions at a classroom, school, and district level.

Further research needs to be extended to a state representative sample of Gujarat students and individual sub-skill growth trajectories tracked over time from grade 6 to grade 8. The implications of the equity findings reported here for the intervention would be directly tested via experimental evaluation of structured thinking skill enrichment interventions targeted specifically at Inference and Generalisation in government school settings with the use of the MTST as a pre-post outcome measure.

ACKNOWLEDGMENTS

The authors thank the Children's Research University, Gandhinagar for full research sponsorship and institutional support under their Collaborative Research Programme in Educational Assessment and Psychometrics, Grant Cycle 2024-26. The funding body was not involved in the design, data collection, analysis or interpretation, or decisions to publish the results of this study. The authors are grateful to the District Education Offices of Anand and Kheda for permission to conduct research; to the 35 schools that participated in the study who facilitated the collection of data; and to the 1,200 students and their families who participated in the study.

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