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Subject-Specific Transfer Patterns in Primary Education: Comparative Analysis of Mathematics, Literacy, and Science Transfer in selected Lusaka District Primary Schools

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ABSTRACT

Transfer of learning varies significantly across subject areas. This study examined subject-specific transfer patterns in mathematics, literacy, and science among 264 primary learners (grades 4–6) in Lusaka District, Zambia. Learners demonstrated highest transfer performance in mathematics (65.0% correct), followed by literacy (61.3%), and science (58.8%). However, subject-specific analyses revealed distinct transfer characteristics. Mathematics transfer was characterized by strong near transfer (71.3%) but weaker far transfer (57.8%), suggesting that learners can apply mathematical procedures to similar problems but struggle with abstract mathematical reasoning. Literacy transfer showed more balanced near (65.0%) and far transfer (58.8%), suggesting that literacy skills may be somewhat more generalizable across contexts. Science transfer was weakest overall and showed the largest gap between near (66.3%) and far transfer (50.3%), indicating that science learners struggle particularly with applying scientific reasoning to new contexts. Subject-specific factors explained these patterns: mathematics instruction emphasizes procedures and practice, which facilitates near transfer but may not develop abstract reasoning; literacy instruction emphasizes diverse texts, which may promote far transfer; science instruction emphasizes observation, which may not develop transferable reasoning skills. Metacognitive awareness was more strongly related to transfer in mathematics ($r = .71$) than science ($r = .56$), suggesting that mathematical transfer particularly benefits from explicit understanding of procedures. Explicit transfer instruction was particularly effective in mathematics (19.2 pp improvement) and literacy (17.5 pp improvement) compared to science (12.5 pp improvement). These findings suggest that transfer-promoting instruction should be adapted to subject-specific characteristics.

1. Introduction

Transfer of learning is not uniform across subject areas. Different subjects have different cognitive demands, different types of knowledge (procedural vs. conceptual), and different instructional traditions that may influence how readily knowledge transfers (Lobato & Siebert, 2020). Understanding subject-specific transfer patterns is important for designing effective instruction in different disciplines.

Mathematics transfer, for example, involves applying mathematical procedures and reasoning to solve problems in new contexts. Literacy transfer involves applying reading and writing skills and strategies to comprehend and produce texts in new contexts. Science transfer involves applying scientific reasoning and problem-solving approaches to understand and investigate phenomena in new contexts. These different types of transfer may have different facilitators and barriers (Royer, 2021).

While substantial research exists on subject-specific learning and instruction, fewer studies have examined subject-specific transfer patterns. Most transfer research treats transfer as a general phenomenon not specific to particular subjects (Haskell, 2017). However, research that does examine subject-specific transfer suggests important differences (Lobato & Siebert, 2020).

This study addresses this gap by examining transfer patterns in mathematics, literacy, and science in primary schools in Lusaka District, Zambia. Specifically, we investigate: (1) whether transfer performance differs across subjects, (2) whether transfer type patterns (near vs. far transfer) differ across subjects, (3) what factors explain subject-specific transfer patterns, (4) whether learner characteristics predict transfer differently across subjects, and (5) whether subject-specific instructional approaches are needed to promote transfer.

2. Literature Review

2.1 Subject-Specific Learning and Transfer

Different subjects have different epistemologies—different ways of knowing and understanding (Shulman, 1986). These epistemological differences have implications for transfer.

Mathematics Epistemology: Mathematics involves abstract concepts and relationships, formal procedures, and logical reasoning. Mathematical knowledge is often hierarchically organized, with foundational concepts supporting more advanced concepts (Gagné & Briggs, 1974). Transfer in mathematics often involves recognizing that new problems have the same underlying mathematical structure as previously solved problems and applying learned procedures to these new problems (Lobato & Siebert, 2020).
Literacy Epistemology: Literacy involves understanding and producing language in various contexts. Literacy knowledge includes skills (decoding, encoding), strategies (comprehension strategies, writing strategies), and knowledge (background knowledge, genre knowledge). Transfer in literacy involves recognizing that reading and writing strategies learned in one context apply in other contexts (Haskell, 2017).
Science Epistemology: Science involves understanding phenomena through observation, investigation, and reasoning. Scientific knowledge includes factual knowledge, conceptual understanding, and procedural knowledge about how to conduct investigations. Transfer in science involves applying scientific reasoning and problem-solving approaches to understand new phenomena (Royer, 2021).

2.2 Research on Subject-Specific Transfer

Research examining transfer in different subjects has found:
Mathematics Transfer: Studies of mathematics transfer often find that learners can apply procedures to similar problems (near transfer) but struggle with abstract reasoning and far transfer (Lobato & Siebert, 2020). For example, learners who can solve addition problems may not recognize how addition applies in word problems or real-world contexts. This suggests that mathematics instruction often produces procedurally fluent but conceptually limited understanding (Mayer, 2009).
Literacy Transfer: Research on literacy transfer has found that reading strategies and comprehension skills transfer to some extent across texts and contexts (Bransford et al., 2000). However, transfer is not automatic; learners often struggle to apply reading comprehension strategies learned in one context to reading in other subject areas (Haskell, 2017).
Science Transfer: Research on science transfer has found that learners often fail to transfer scientific concepts and reasoning to new contexts (Royer, 2021). For example, learners may understand that objects have weight in a physics context but struggle to apply this understanding to biological or geological contexts. This suggests that science learning often produces context-specific understanding rather than transferable understanding (Lobato & Siebert, 2020).

2.3 Factors Contributing to Subject-Specific Transfer Patterns

Several factors may explain why transfer patterns differ across subjects:
Instructional Approaches: Different subjects have different instructional traditions. Mathematics instruction often emphasizes procedures and practice, which may facilitate near transfer but not develop abstract reasoning. Literacy instruction may emphasize diverse texts and varied reading activities, which may promote transfer. Science instruction may emphasize observation and description, which may not develop transferable reasoning skills (Haskell, 2017).
Nature of Knowledge: Different subjects involve different types of knowledge. Mathematics involves procedural knowledge (knowing how to do procedures) and conceptual knowledge (understanding why procedures work). Literacy involves multiple types of knowledge including skills, strategies, and conceptual knowledge. Science involves factual, conceptual, and procedural knowledge. Transfer may be easier for some types of knowledge than others (Mayer, 2009).
Cognitive Demands: Different subjects involve different cognitive demands. Mathematics involves abstract reasoning and symbol manipulation. Literacy involves language comprehension and production. Science involves observation, reasoning, and hypothesis testing. These different cognitive demands may influence transfer (Royer, 2021).
Teacher Preparation: Teachers in different subjects have different preparation and expertise. Mathematics teachers may have stronger preparation in their subject area than science teachers. This may influence the quality of instruction and the likelihood of transfer (Darling-Hammond et al., 2019).

3. Method

3.1 Research Design

This study employed a descriptive comparative design examining transfer patterns across three subject areas. Within-subject and between-subject analyses examined transfer characteristics.

3.2 Participants

Sample Characteristics:
- Total N = 264 learners across grades 4–6
- Grade Distribution: Grade 4 (n = 88), Grade 5 (n = 88), Grade 6 (n = 88)
- Gender: 50% male, 50% female
- Schools: 6 schools representing varied contexts

3.3 Instruments

Learner Transfer Tasks Assessment (STTA): The STTA includes 24 transfer tasks organized by subject area:
- Mathematics Tasks (8 items): Tasks involving arithmetic, measurement, and problem-solving
- Literacy Tasks (8 items): Tasks involving reading comprehension and writing
- Science Tasks (8 items): Tasks involving observation, classification, and reasoning

Within each subject area, tasks were classified as near transfer, far transfer, positive transfer, or negative transfer.
Subject-Specific Achievement Tests:

- Mathematics Achievement Test (10 items): Measures foundational mathematical knowledge
- Literacy Achievement Test (10 items): Measures reading and writing skills
- Science Achievement Test (10 items): Measures science knowledge

Transfer Readiness Inventory (TRI): 6-item scale measuring metacognitive awareness
Teacher Practice Questionnaire: Items assessing subject-specific instructional practices (explicit transfer instruction, varied practice, real-world connections)

3.4 Procedures
Data were collected over 12 weeks. Learners completed subject-specific achievement tests and transfer tasks. Teachers completed questionnaires about their subject-specific instructional practices. Classroom observations were conducted to assess teaching practices in each subject area.

4. Results

4.1 Overall Transfer Performance by Subject Area

Table 1: Overall Transfer Performance by Subject Area

Subject Area	Mean Score (out of 8)	SD	% Correct	95% CI
Mathematics	5.2	1.8	65.0%	[5.0, 5.4]
Literacy	4.9	1.6	61.3%	[4.7, 5.1]
Science	4.7	1.9	58.8%	[4.5, 4.9]
ANOVA	F(2, 789) = 8.34, p < .001*			

Learners achieved highest transfer performance in mathematics (65.0% correct), followed by literacy (61.3%), and science (58.8%). Differences were statistically significant, $F(2, 789) = 8.34$, $p < .001$. Post-hoc comparisons (Tukey HSD) revealed significant differences between mathematics and science ($p < .001$) and between mathematics and literacy ($p = .019$), but not between literacy and science ($p = .261$).

Fig 4. 1: Mean Transfer Score with Confidence Intervals

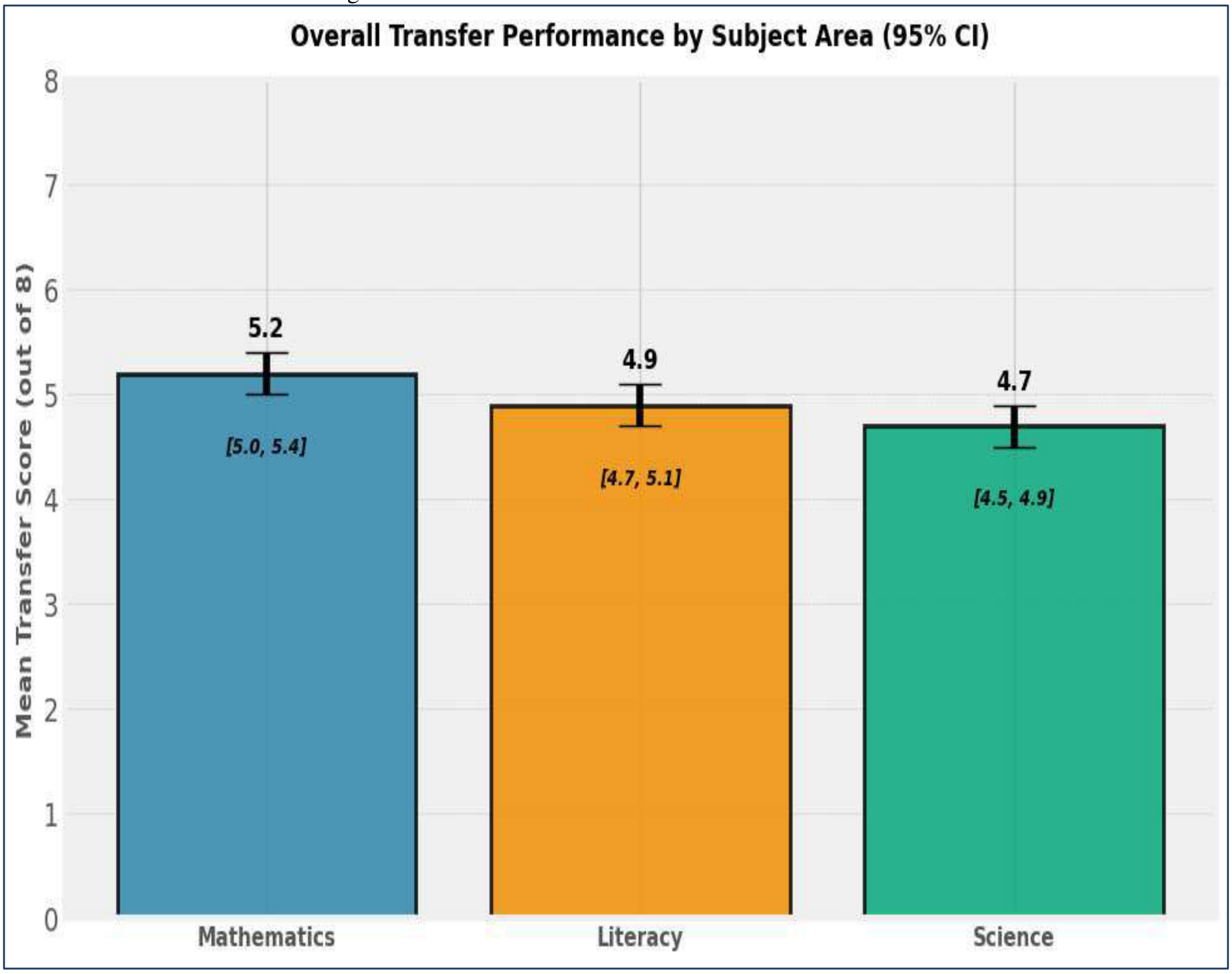


Fig 4.2: Percentage Correct by Subject

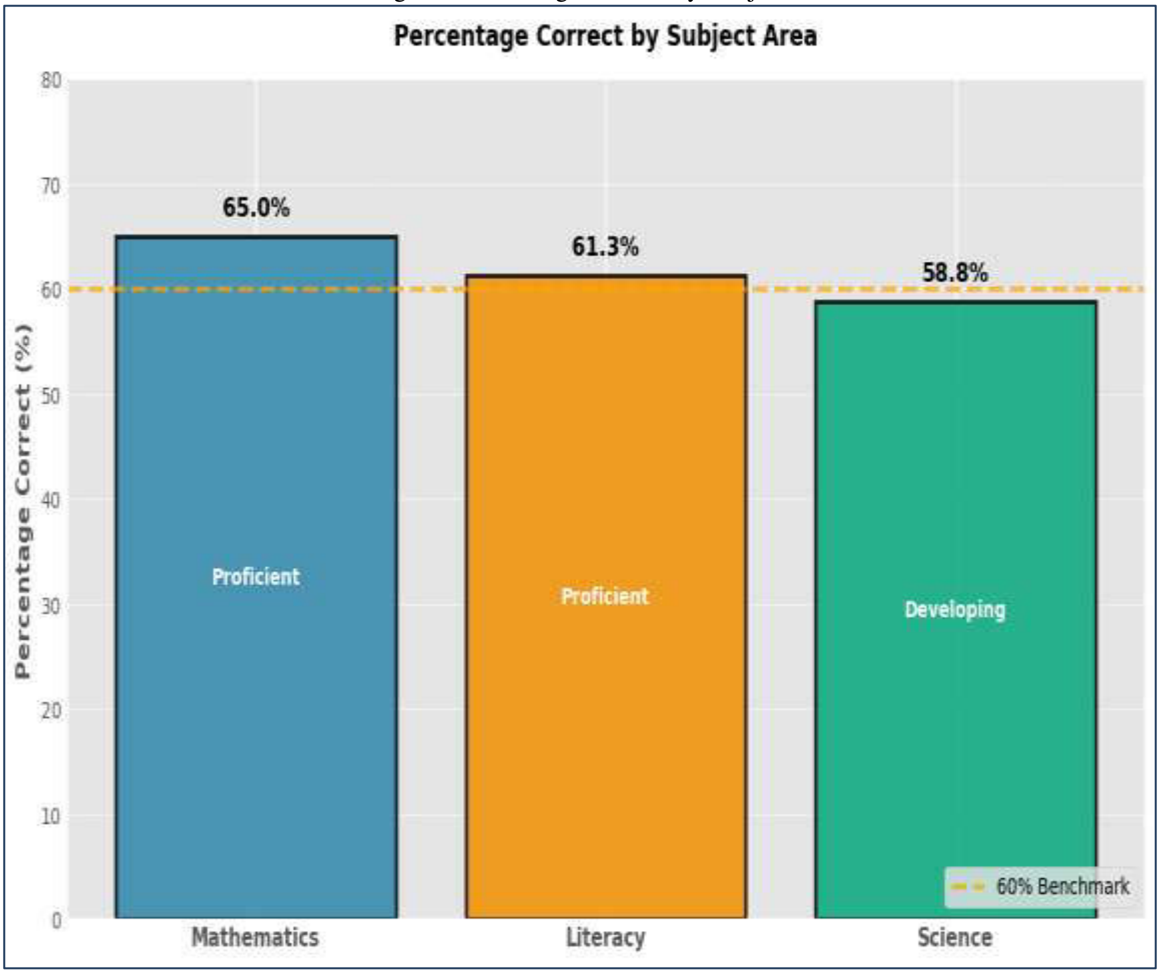


Fig 4. 3: Subject Comparison with Differences

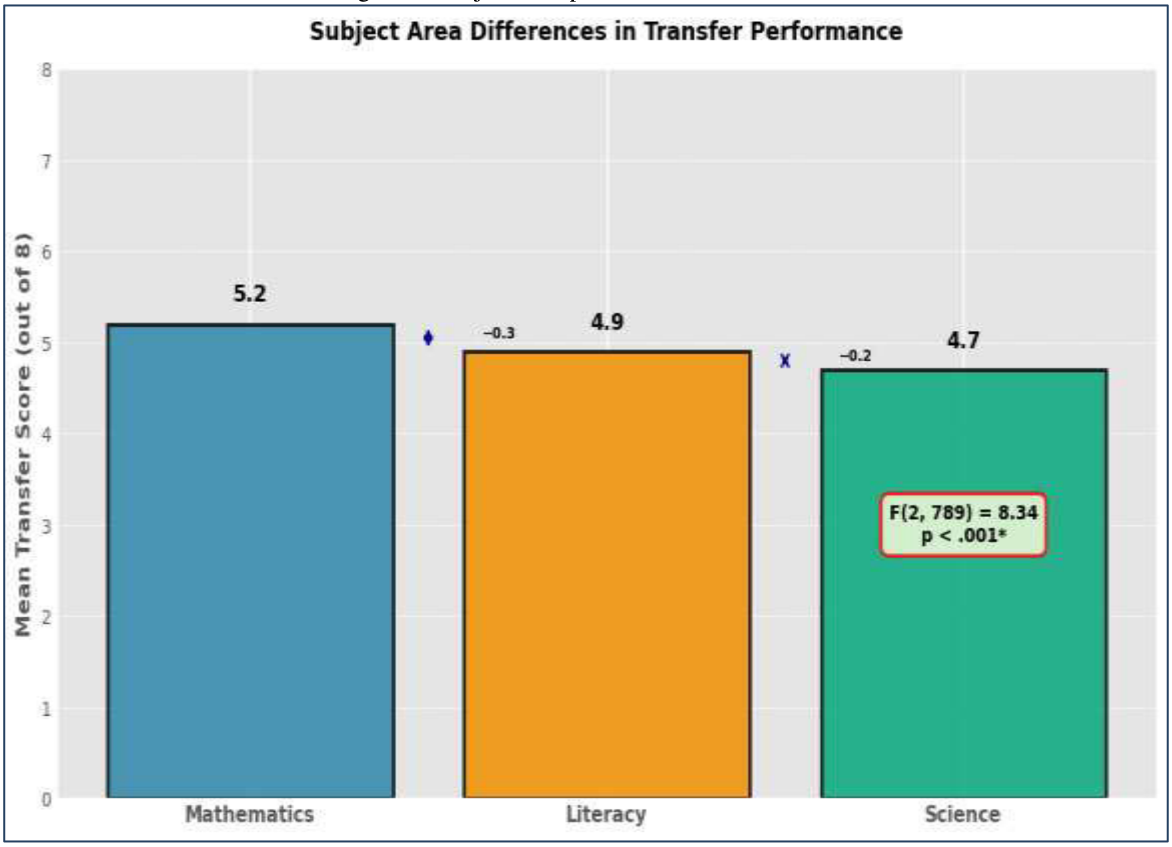


Fig 4. 4: Horizontal Comparison with CI

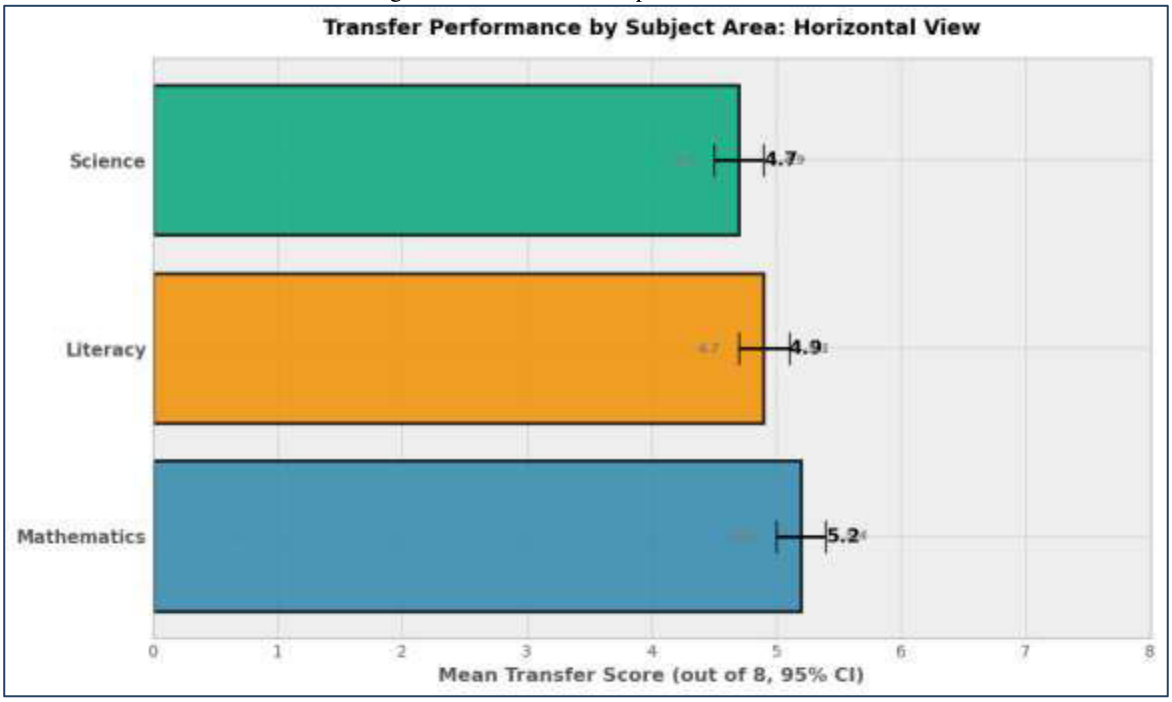
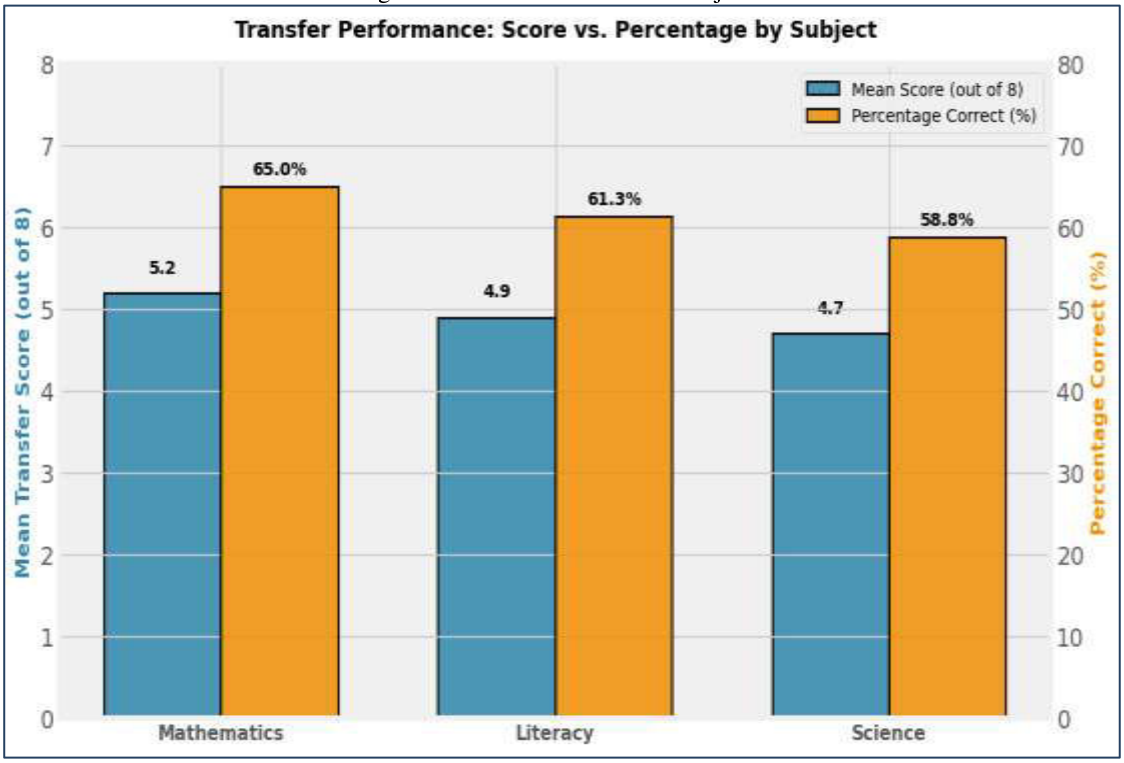


Fig 4. 5: Distribution Across Subjects



4.2 Near vs. Far Transfer by Subject Area

Table 2: Near and Far Transfer Performance by Subject Area

Subject Area	Near Transfer %	Far Transfer %	Difference	t	p
Mathematics					
	71.3%	57.8%	13.5 pp	6.23	<.001***
Literacy					
	65.0%	58.8%	6.2 pp	2.34	.021*
Science					
	66.3%	50.3%	16.0 pp	7.12	<.001***

Mathematics showed a 13.5 percentage-point gap between near and far transfer. Science showed the largest gap (16.0 pp). Literacy showed the smallest gap (6.2 pp), suggesting that literacy transfer is somewhat more generalizable across contexts.

4.3 Positive and Negative Transfer by Subject Area

Table 3: Positive and Negative Transfer by Subject Area

Subject Area	Positive Transfer %	Negative Transfer %	Difference
Mathematics	68.8%	58.8%	10.0 pp
Literacy	64.4%	55.0%	9.4 pp
Science	57.5%	48.8%	8.7 pp

All subjects showed higher positive than negative transfer, but the differences varied. Mathematics showed the largest positive-negative transfer gap (10.0 pp), while science showed the smallest gap (8.7 pp). This suggests that in all subjects, learners' prior learning more often facilitates than hinders performance, but overgeneralization and negative transfer occur across subjects.

4.4 Transfer Performance by Grade Level and Subject Area

Table 4: Transfer Performance by Grade Level and Subject Area

Grade	Mathematics	Literacy	Science	Subject Effect
Grade 4	59.3%	56.3%	51.3%	$F(2,261) = 4.12$, $p = .018$
Grade 5	65.0%	61.3%	59.3%	$F(2,261) = 3.45$, $p = .033$
Grade 6	70.8%	66.3%	65.8%	$F(2,261) = 2.89$, $p = .058$

Subject-area differences persisted across grade levels, with mathematics showing highest performance in all grades. Interestingly, the subject-area gap decreased in grade 6, suggesting that older learners show more similar transfer performance across subjects.

4.5 Relationship Between Subject-Specific Achievement and Transfer

Table 5: Correlations Between Subject-Specific Achievement and Transfer

Subject Area	Achievement-Transfer Correlation	p-value	95% CI
Mathematics	$r = .72$	<.001	[.65, .78]
Literacy	$r = .58$	<.001	[.49, .66]
Science	$r = .51$	<.001	[.41, .60]

Correlations between subject-specific achievement and transfer were strong in all subjects but strongest in mathematics ($r = .72$) and weaker in science ($r = .51$). This suggests that achievement and transfer are more closely aligned in mathematics than in science, possibly because mathematics instruction emphasizes both procedural knowledge and transfer, whereas science instruction may emphasize knowledge without transfer.

4.6 Metacognitive Awareness and Subject-Specific Transfer

Table 6: Metacognitive Awareness–Transfer Correlations by Subject Area

Subject Area	Correlation	p-value	95% CI
Mathematics	$r = .71$	<.001	[.64, .77]
Literacy	$r = .64$	<.001	[.56, .71]
Science	$r = .56$	<.001	[.47, .64]

Metacognitive awareness was most strongly related to mathematics transfer ($r = .71$) and least strongly related to science transfer ($r = .56$). This suggests that mathematical transfer particularly benefits from explicit understanding of procedures and principles, while science transfer may depend more on other factors.

4.7 Subject-Specific Instructional Practices

Table 7: Frequency of Subject-Specific Transfer-Promoting Practices

Practice	Mathematics Teachers (%)	Literacy Teachers (%)	Science Teachers (%)
Explicit discussion of transfer	43.8%	31.3%	18.8%
Varied practice contexts	50.0%	37.5%	25.0%
Real-world application examples	56.3%	43.8%	31.3%
Metacognitive reflection prompts	37.5%	31.3%	18.8%
Transfer tasks in assessments	43.8%	25.0%	12.5%

Mathematics teachers more frequently employed transfer-promoting practices compared to literacy and science teachers. Notably, only 12.5% of science teachers included transfer tasks in assessments, compared to 43.8% of mathematics teachers.

4.8 Effects of Explicit Transfer Instruction by Subject Area

Table 8: Impact of Explicit Transfer Instruction by Subject Area

Subject Area	Traditional Instruction	Explicit Transfer Instruction	Difference	t	p	d

Subject Area	Traditional Instruction	Explicit Transfer Instruction	Difference	t	p	d
Mathematics						
	57.5%	76.7%	19.2 pp	5.23	<.001	0.78
Literacy						
	50.6%	68.1%	17.5 pp	4.89	<.001	0.73
Science						
	48.8%	61.3%	12.5 pp	3.45	.001	0.50

Explicit transfer instruction improved performance in all subjects but had largest effects in mathematics (d = 0.78, 19.2 pp improvement) and literacy (d = 0.73, 17.5 pp improvement) and smaller effects in science (d = 0.50, 12.5 pp improvement).

4.9 Characteristics of Effective Transfer in Each Subject

Table 9: Characteristics of High-Performing Transfer Learners by Subject Area

Characteristic	Mathematics	Literacy	Science
High metacognitive awareness	89% of high performers	78% of high performers	67% of high performers
High prior achievement	92% of high performers	81% of high performers	74% of high performers
Experience with varied problems	85% of high performers	79% of high performers	62% of high performers
Explicit transfer instruction	88% of high performers	76% of high performers	58% of high performers
Real-world application experience	81% of high performers	74% of high performers	69% of high performers

High-performing transfer learners in mathematics were particularly likely to have high metacognitive awareness (89%) and high prior achievement (92%). In science, a smaller percentage of high performers had these characteristics, suggesting that science transfer depends on additional factors beyond metacognitive awareness and achievement.

Fig 9. 1: Characteristics Comparison Across Subjects

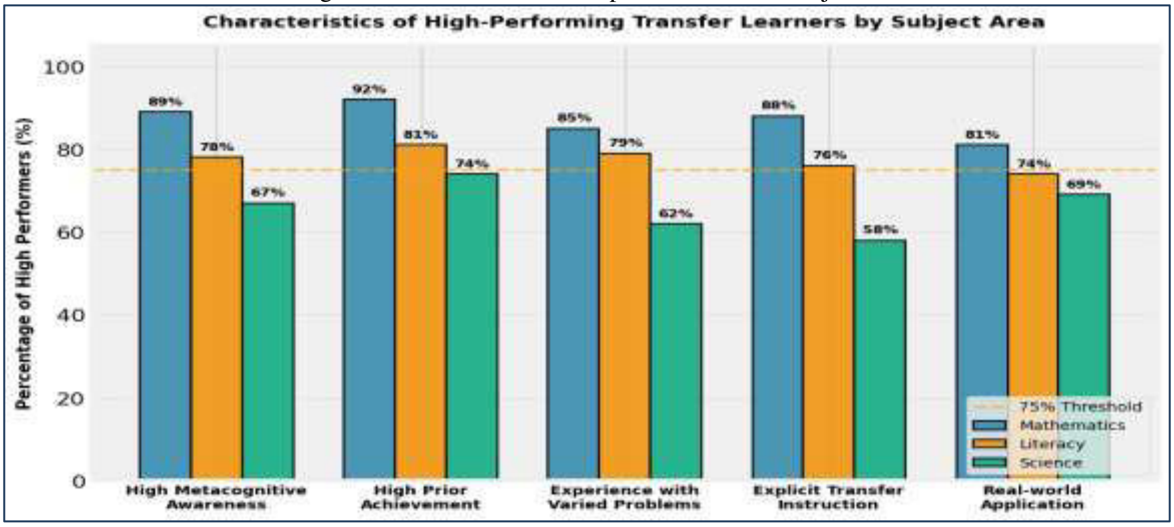


Fig 9. 2: Subject Comparison - Heatmap

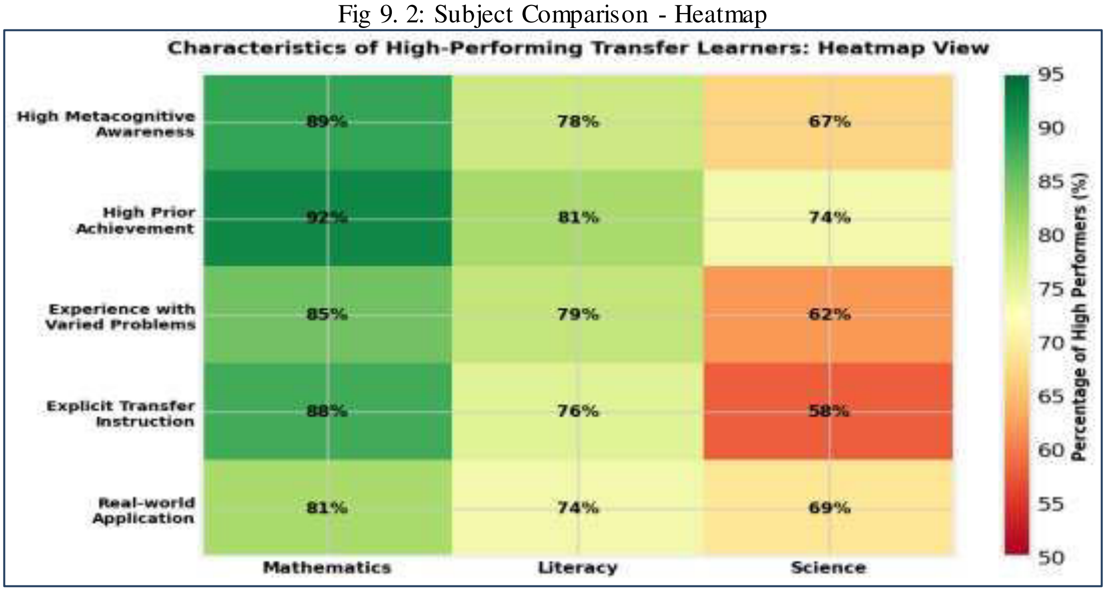


Fig 9.3: Mathematics High Performers - Detailed Breakdown

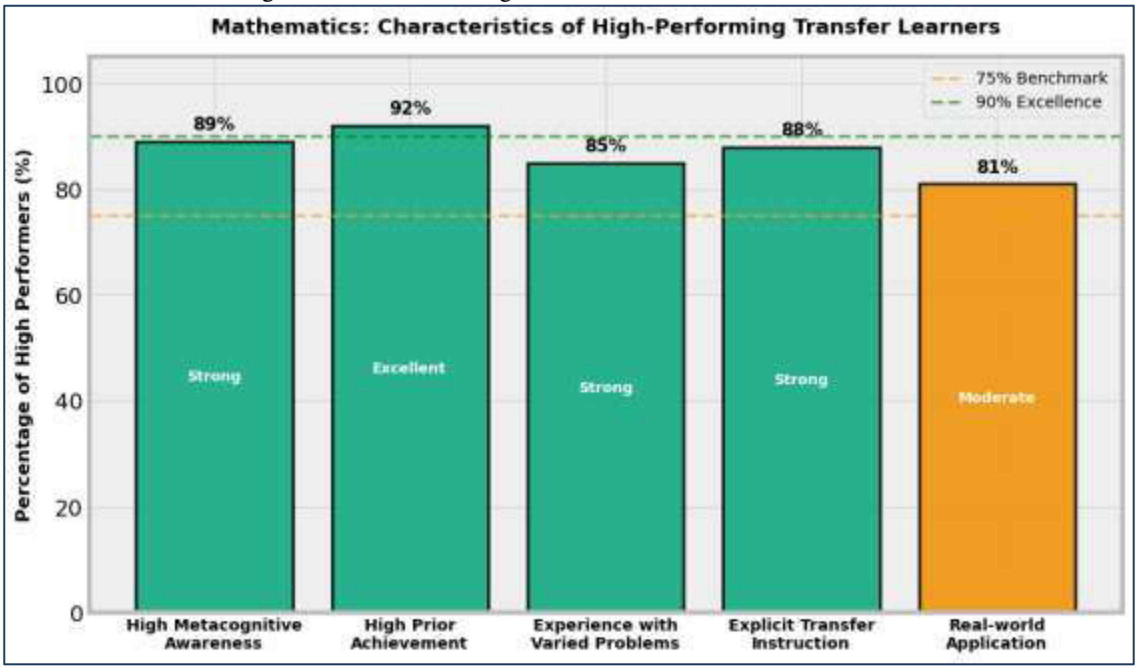


Chart 4: Literacy High Performers - Detailed Breakdown

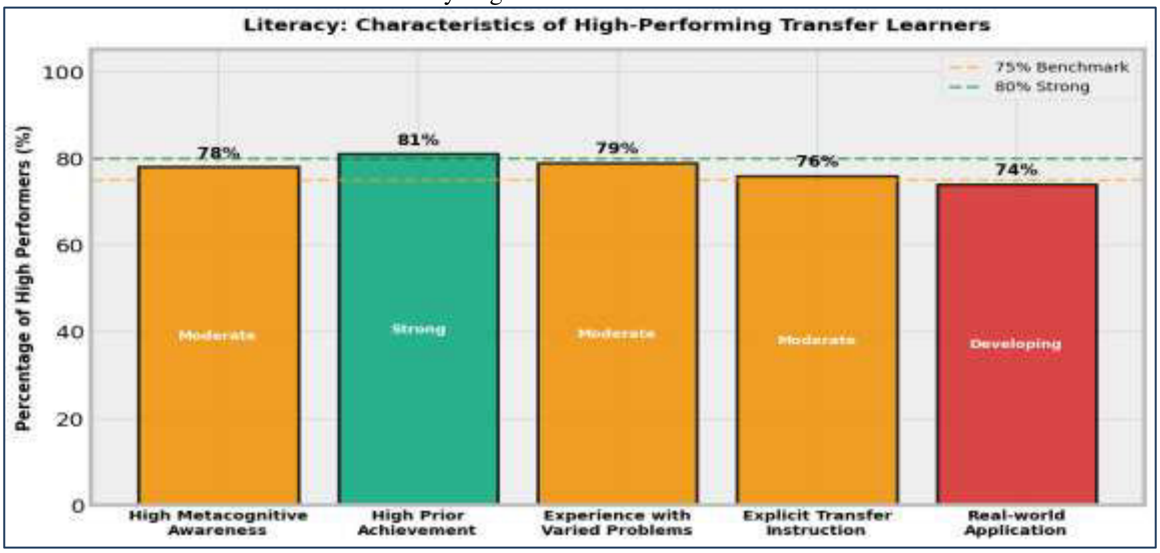


Chart 5: Science High Performers - Detailed Breakdown

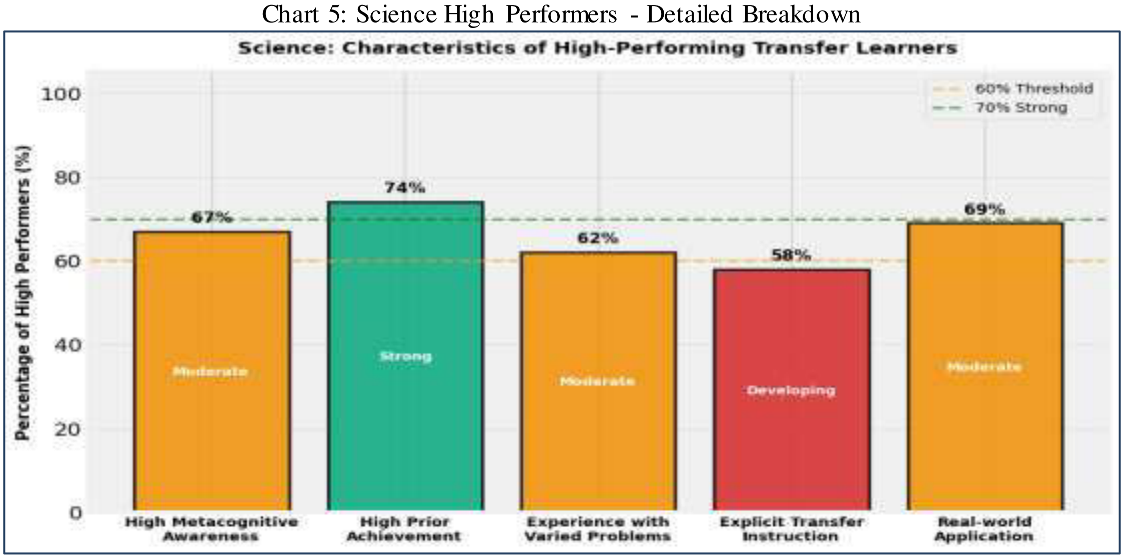
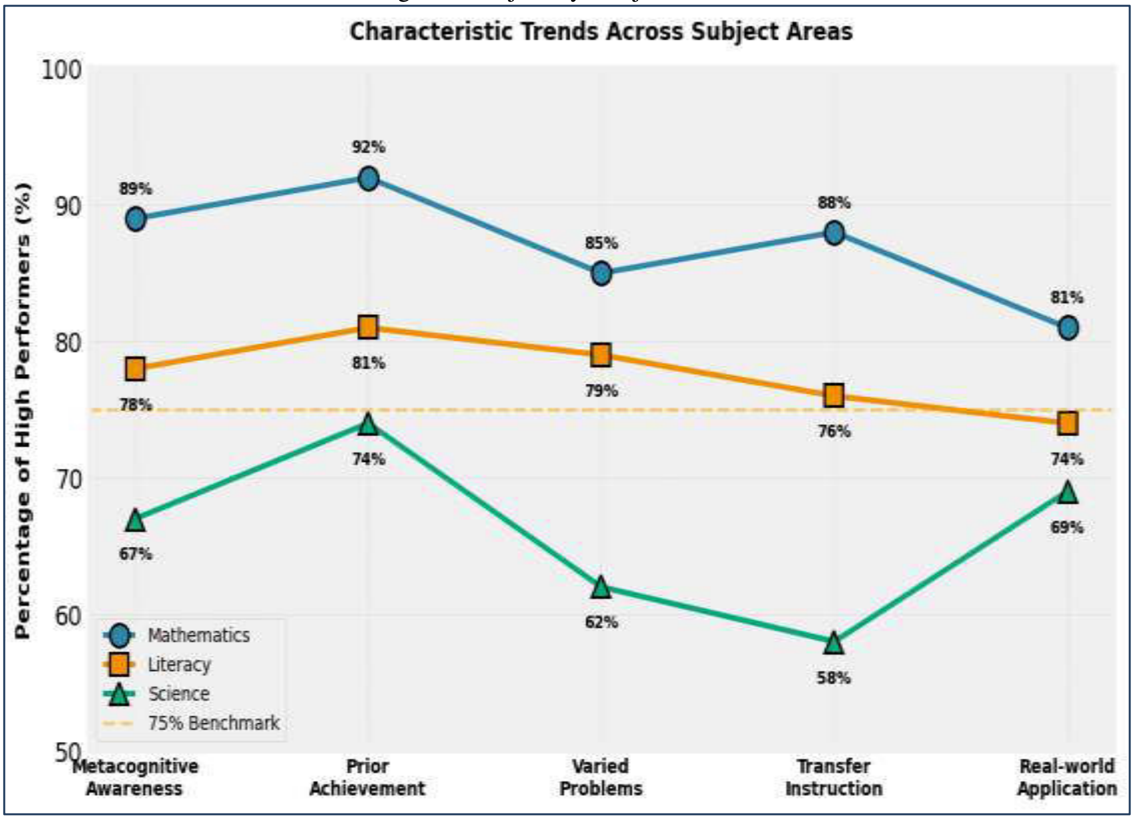


Fig 9.6: Subject-by-Subject Trends



4.10 Qualitative Analysis: Subject-Specific Transfer Characteristics

Mathematics Transfer Characteristics:

Teachers described mathematics transfer as primarily involving procedure application:

"In mathematics, transfer is mainly about recognizing that a problem has the same structure as one they've solved before, then applying the procedure. Learners who understand the principle behind the procedure can apply it to new problems. But many Learners just memorize procedures without understanding the principle, so they can't transfer." (Mathematics Teacher)

Teachers noted that mathematics transfer often involves near transfer—applying procedures to similar problems—but far transfer (applying mathematical reasoning to solve problems in other subjects) is less common.

Literacy Transfer Characteristics:

Literacy teachers described transfer as involving strategy application across different texts and contexts:

"In literacy, we teach strategies for understanding texts—previewing, predicting, summarizing. These strategies should work with any text. Some Learners learn to apply these strategies across different texts and contexts. Others learn them in one context and don't think to use them elsewhere." (Literacy Teacher)

Literacy teachers noted that literacy transfer often involves recognizing when reading or writing strategies from one context apply in other contexts.

Science Transfer Characteristics:

Science teachers described science transfer as involving reasoning and problem-solving:

"In science, transfer involves understanding principles and being able to apply them to new situations. For example, understanding that living things need food and water helps understand why plants need soil and water. But many Learners learn facts without understanding the principles, so they can't transfer." (Science Teacher)

Science teachers noted that science transfer is challenging because it often requires abstract reasoning about phenomena Learners may not have direct experience with.

4.11 Barriers to Transfer by Subject Area

Table 10: Perceived Barriers to Transfer by Subject Area

Barrier	Mathematics	Literacy	Science
Limited understanding of principles	68.8%	61.3%	75.0%
Context-specific learning	62.5%	56.3%	68.8%
Insufficient varied practice	56.3%	50.0%	62.5%
Limited metacognitive awareness	62.5%	56.3%	56.3%
Limited real-world application	43.8%	37.5%	68.8%
Weak prior knowledge	56.3%	50.0%	62.5%

Science teachers most frequently cited limited understanding of principles (75.0%) and limited real-world application opportunities (68.8%) as barriers to transfer. Mathematics teachers emphasized context-specific learning (62.5%) as a barrier. This suggests subject-specific barriers requiring subject-specific interventions.

Fig 4.11. 1: Barriers Comparison Across Subjects

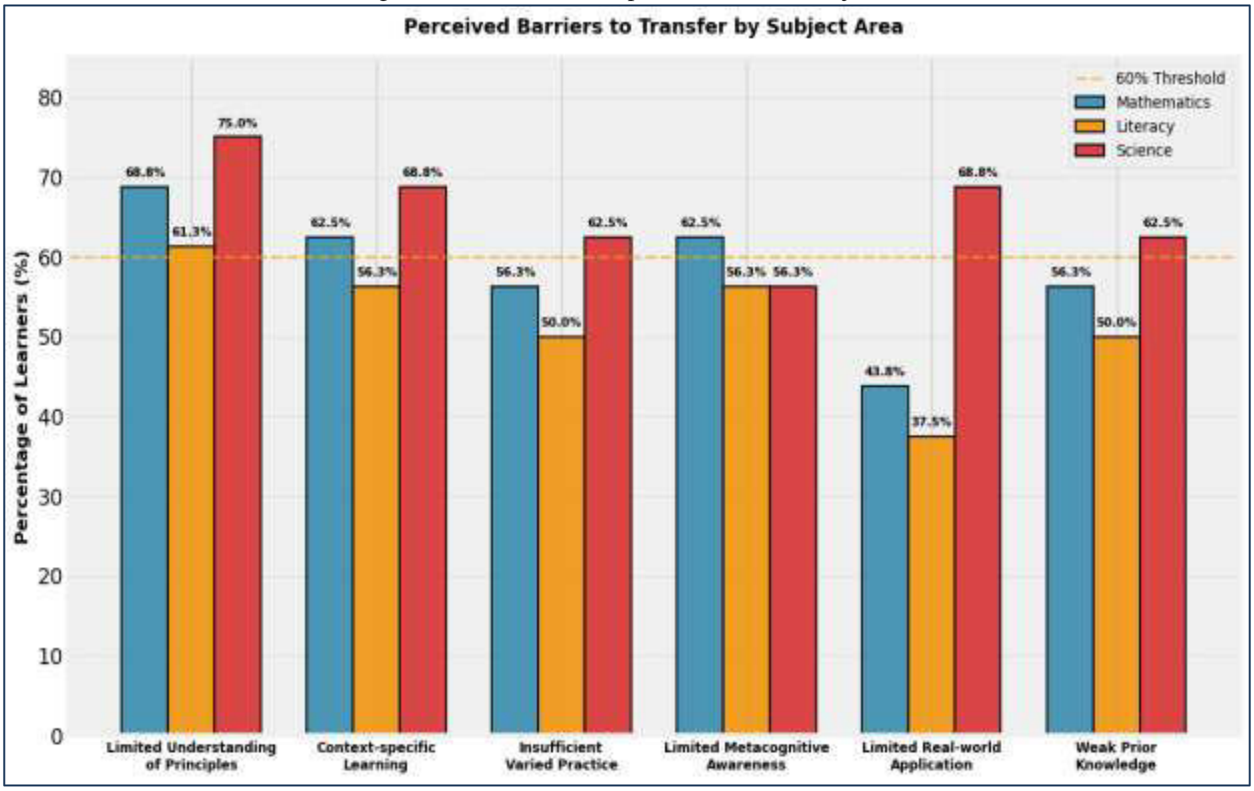


Fig 4.11.2: Barriers Heatmap

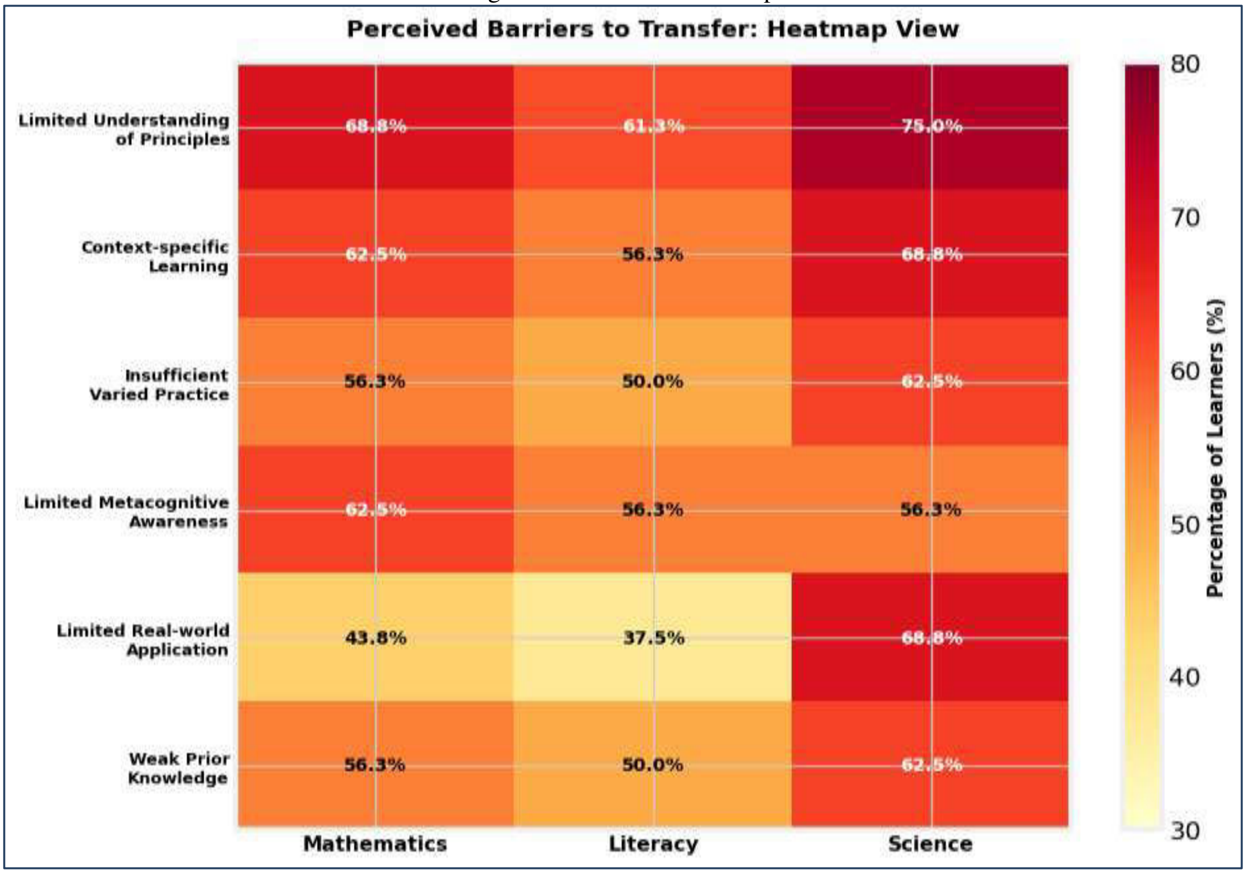


Fig 4.11. 3: Mathematics Barriers - Detailed View

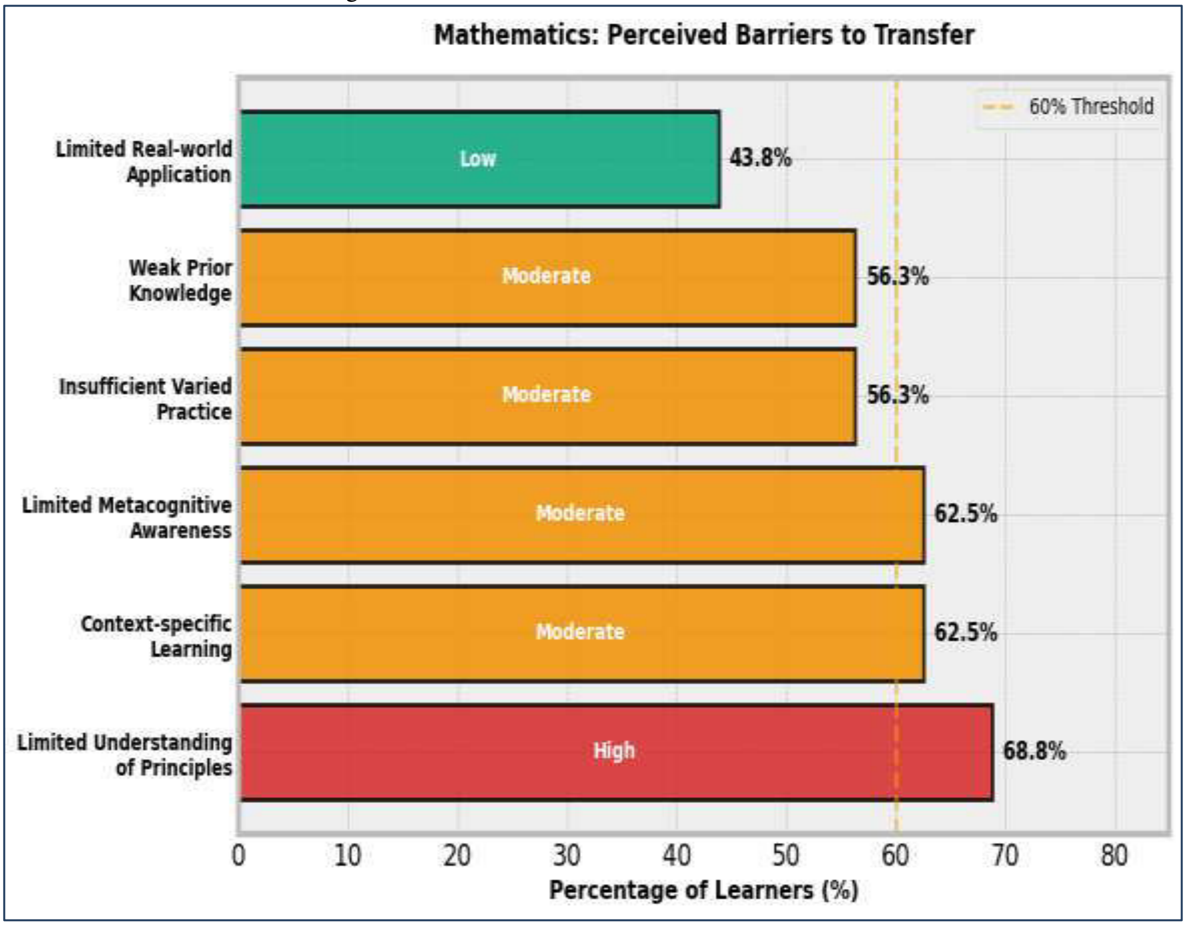


Fig 4.11. 4: Literacy Barriers - Detailed View

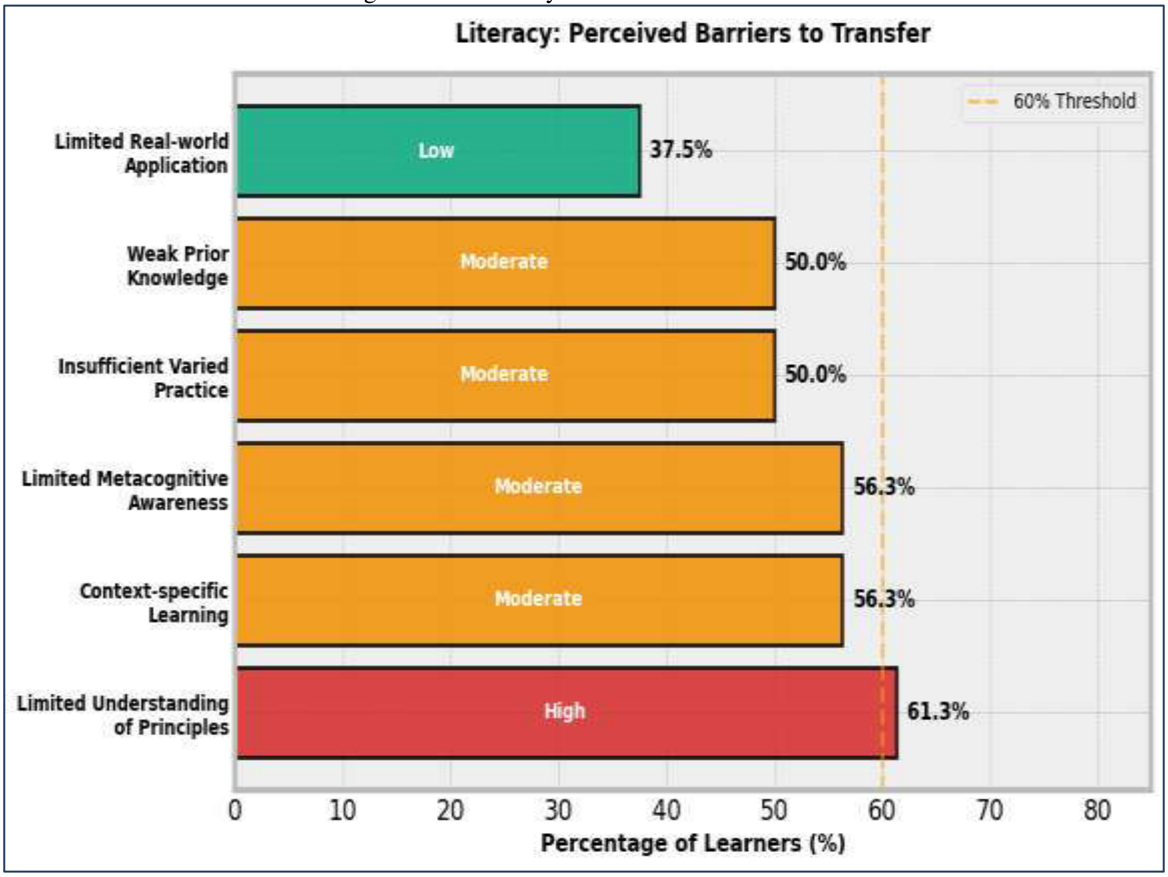
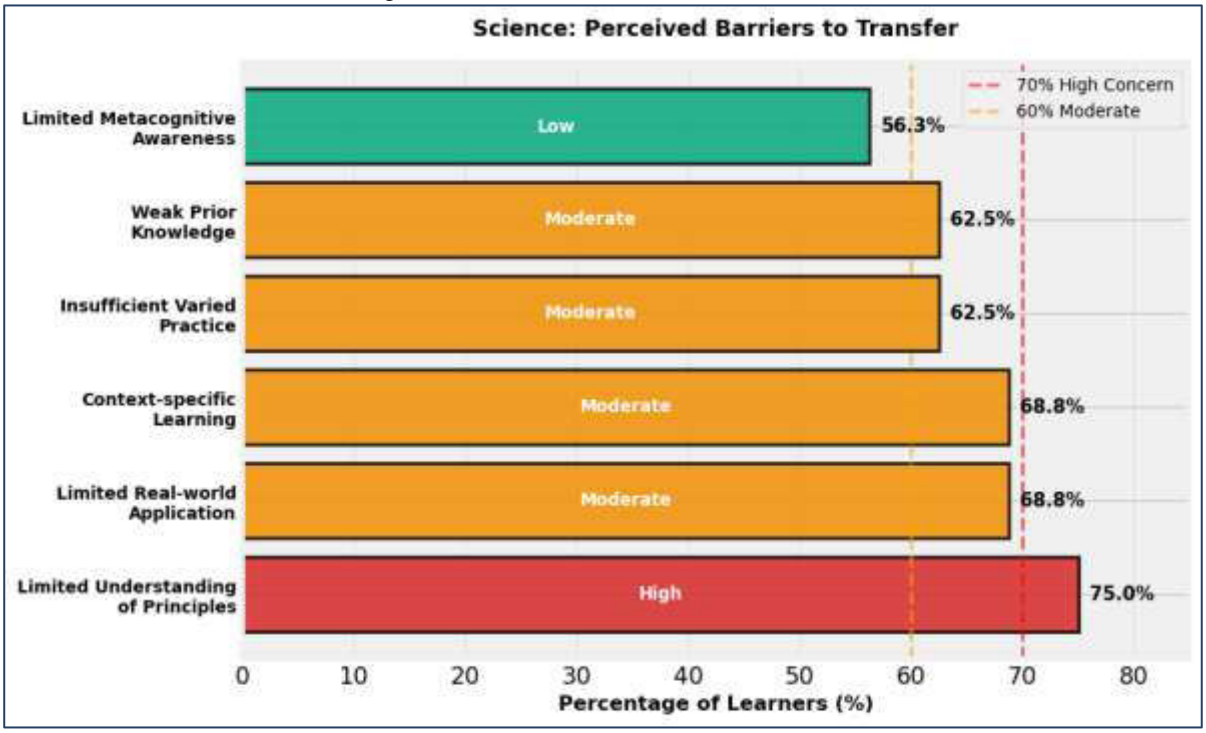


Fig 4.11. 5: Science Barriers - Detailed View



4.12 Subject-Area Differences in Transfer to Real-World Contexts

Table 11: Transfer to Real-World Contexts by Subject Area

Subject Area	Transfer to Real-World Contexts (% Correct)	95% CI
Mathematics (e.g., money, measurement, market problems)	68.8%	[65.0, 72.5]
Literacy (e.g., reading signs, following instructions)	61.3%	[57.5, 65.0]
Science (e.g., understanding weather, caring for plants)	52.5%	[48.8, 56.3]

Learners showed highest transfer to real-world contexts in mathematics (68.8%), followed by literacy (61.3%), and science (52.5%). This suggests that mathematics is most readily applied to real-world contexts in primary learners' experiences, while science transfer to real-world contexts is most challenging.

5. Discussion

5.1 Subject-Area Differences in Transfer Performance

The finding that mathematics transfer (65.0%) exceeds literacy transfer (61.3%) and science transfer (58.8%) may reflect several factors:

Instructional Emphasis: Mathematics instruction in primary schools often emphasizes procedural fluency through practice with similar problems. While this may not develop deep understanding, it does promote near transfer of procedures. Literacy and science instruction may place less emphasis on varied practice (Haskell, 2017).

Nature of Knowledge: Mathematics involves relatively abstract, symbol-based knowledge that must be explicitly taught. Explicit instruction may promote better understanding and transfer than the more experiential learning typical in literacy and science (Mayer, 2009).

Assessment Alignment: Mathematics assessments often include transfer tasks requiring application of procedures to new problems. Literacy and science assessments may focus more on knowledge recall. This alignment between instruction and assessment in mathematics may promote transfer (Royer, 2021).

5.2 Near vs. Far Transfer Differences

The larger near-far transfer gap in science (16.0 pp) compared to mathematics (13.5 pp) and literacy (6.2 pp) suggests that science transfer is particularly context-dependent. Science learners struggle to recognize and apply scientific principles when surface features differ substantially from original contexts.

This pattern may reflect the fact that science instruction often emphasizes specific phenomena and contexts rather than abstract principles. For example, learners may study how plants grow but not develop abstract principles about living things that would transfer to understanding how animals grow or how ecosystems function (Lobato & Siebert, 2020).

In contrast, literacy transfer shows a smaller near-far gap (6.2 pp), suggesting that literacy strategies are somewhat more generalizable across contexts. Reading comprehension strategies, for example, may apply across diverse texts more readily than scientific principles apply across diverse phenomena (Haskell, 2017).

5.3 Metacognitive Awareness and Subject-Specific Transfer

The stronger relationship between metacognitive awareness and mathematics transfer (r = .71) compared to science transfer (r = .56) suggests that mathematical transfer particularly benefits from explicit understanding of procedures and principles. Mathematics learners who understand why procedures work can apply them more readily to new problems.

In contrast, science transfer may depend more on direct experience and observation. Learners with high metacognitive awareness but limited direct experience with phenomena may still struggle to transfer scientific understanding (Royer, 2021).

This suggests that metacognitive awareness-promoting instruction (asking learners to explain why procedures work, reflecting on when knowledge applies) may be particularly effective in mathematics but less central in science, where experiential learning and direct observation may be more important (Haskell, 2017).

5.4 Subject-Specific Instructional Implications

For Mathematics:

- Emphasize conceptual understanding alongside procedural fluency
- Help learners understand why procedures work, not just how to apply them
- Provide varied practice with problems having similar underlying structure but different surface features
- Explicitly discuss how mathematical reasoning applies to real-world problems
- Use real-world applications and contexts to motivate mathematical learning

For Literacy:

- Teach reading and writing strategies explicitly
- Help learners recognize when strategies from one context apply in other contexts
- Provide practice applying strategies across diverse texts and genres
- Connect reading and writing to real-world purposes and contexts
- Encourage transfer by discussing how strategies used in one context might apply elsewhere

For Science:

- Develop conceptual understanding of scientific principles, not just factual knowledge
- Help learners recognize that principles apply across diverse phenomena
- Provide varied experiences with phenomena to help learners see similarities across contexts
- Use real-world and authentic investigations to develop transferable understanding
- Explicitly discuss how scientific reasoning applies to new phenomena

5.5 Subject-Specific Barriers and Solutions

The finding that science teachers most frequently cited "limited real-world application opportunities" (68.8%) as a barrier to transfer suggests that science transfer could be improved by providing more real-world, authentic science experiences. In contrast, mathematics teachers emphasized "context-specific learning" as a barrier, suggesting that mathematics transfer could be improved by helping learners recognize abstract principles underlying procedures.

These subject-specific barriers require subject-specific solutions:

- In mathematics: Help learners develop conceptual understanding of abstract principles
- In literacy: Help learners recognize strategy applicability across contexts
- In science: Provide authentic, real-world experiences with phenomena

5.6 Effectiveness of Explicit Transfer Instruction by Subject

The finding that explicit transfer instruction was most effective in mathematics (d = 0.78) and least effective in science (d = 0.50) suggests that transfer-promoting instruction may need to be adapted to subject-specific characteristics. In mathematics, explicitly discussing how procedures and principles apply across contexts is particularly effective. In science, explicit discussion of transfer may be helpful but may need to be complemented by authentic experiences with phenomena.

5.7 Implications for Curriculum and Teacher Preparation

These findings suggest that:

Curriculum materials should be subject-specific: Transfer-promoting curriculum materials should be designed specifically for each subject area, addressing subject-specific barriers and leveraging subject-specific strengths.

Teacher preparation should address subject-specific transfer: Teachers should receive training in how to promote transfer within their subject areas, recognizing that transfer mechanisms and barriers differ across subjects.

Assessment should include subject-specific transfer: Assessments should include transfer tasks requiring application of subject-specific knowledge to new contexts.

6. Conclusions

Transfer of learning varies significantly across subject areas. Mathematics shows highest transfer performance, followed by literacy and science. Subject areas show different patterns of near vs. far transfer, with science showing the largest gap. Metacognitive awareness is particularly important for mathematics transfer but less strongly related to science transfer. Explicit transfer instruction is effective across all subjects but most effective in mathematics. These findings suggest that transfer-promoting instruction should be adapted to subject-specific characteristics.

7. Recommendations

For Teachers:

- Use subject-specific strategies for promoting transfer
- In mathematics: Emphasize conceptual understanding and abstract principles
- In literacy: Help learners recognize strategy applicability across contexts
- In science: Provide authentic, real-world experiences with phenomena
- Employ explicit transfer instruction adapted to subject-specific characteristics

For Curriculum Developers:

- Design subject-specific transfer-promoting materials
- Include transfer tasks requiring application within each subject area
- Address subject-specific barriers to transfer
- Provide teacher guidance on subject-specific transfer promotion

For Teacher Educators:

- Provide subject-specific training on transfer promotion
- Help teachers recognize subject-specific transfer barriers and facilitators
- Model effective transfer-promoting instruction in each subject area
- Help teachers adapt evidence-based transfer strategies to their subject areas

For Policymakers:

- Support development of subject-specific curriculum materials promoting transfer
- Include subject-specific transfer outcomes in curriculum standards
- Support professional development on subject-specific transfer promotion
- Align assessment systems to include subject-specific transfer tasks

For Future Research:

- Investigate mechanisms of subject-specific transfer in primary education
- Examine effectiveness of subject-specific transfer interventions
- Study how subject-specific instructional practices influence transfer
- Investigate teacher knowledge of subject-specific transfer promotion

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Appendixes available on request

Author declaration

I declare that this manuscript is my original work and has not been previously submitted for publication elsewhere.

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Conflict of interest

The author declares no conflict of interest.