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Author(s)	Sally Ann Jones, Yeo Rei-Chi Lauren, Yeo Kai Kow Joseph, Mark Fifer Seilhamer, Loh Mei Yoke and Ho Hsien Lin
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TRANSFER OF LEARNING IN ENGLISH AND MATHEMATICS: SINGAPOREAN PRIMARY CLASSROOMS BOOKLET 3

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THE TEAM

Dr. Sally Ann Jones
Principal Investigator
Senior Lecturer
English Language and Literature Academic Group (ELL/AG),
National Institute of Education

Dr. Yeo Kai Kow Joseph
Co-Principal Investigator
Senior Lecturer
Mathematics and Mathematics Education Academic Group (MME/AG),
National Institute of Education

Dr. Mark Fifer Seilhamer
Co-Principal Investigator
Lecturer
English Language and Literature Academic Group (ELL/AG),
National Institute of Education

Dr. Loh Mei Yoke
Co-Principal Investigator
Lead Curriculum Specialist,
Curriculum Planning and Development Division (CPDD),
Ministry of Education

Ms. Ho Hsien Lin
Co-Principal Investigator
English Language Teacher
Ai Tong School
Subject Literacy Officer (2015-2017),
English Language Institute of Singapore (ELIS)

Miss Yeo Rei-Chi Lauren
Research Assistant
English Language and Literature Academic Group (ELL/AG),
National Institute of Education

CONTENTS

THE RESEARCH STUDY

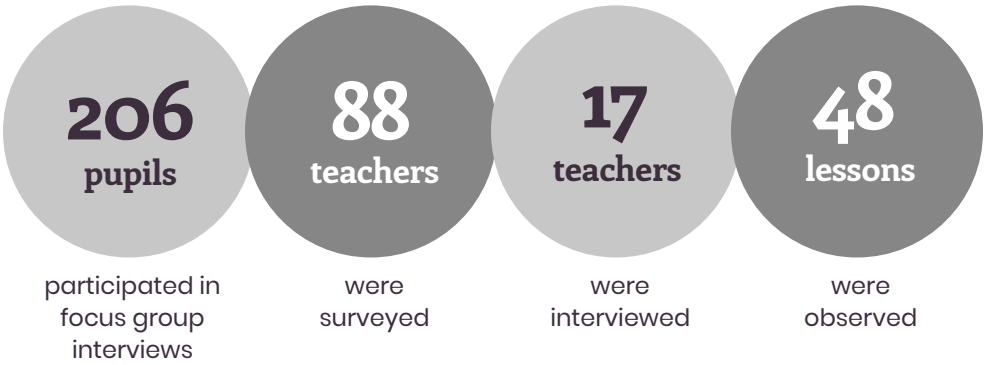
Background of the Research

This booklet presents some key findings about transfer of learning from a research study which explored pupil and teacher perceptions and experiences of teaching and learning mathematics and English in Singaporean primary school classrooms. It also draws together some of the key findings of booklets 1 (mathematics) and 2 (English) of this series of three booklets. This booklet presents findings from the following research questions:

- What are pupils' views about and experiences of learning mathematics and English at school and elsewhere at primary one (P1), three (P3), and five (P5)?
- How far and at what level/s are pupils able to transfer and apply the language taught in English lessons to their learning of mathematics and how far is their knowledge of English sufficient and useful for the demands of learning mathematics?
- What are English and mathematics teachers' practices and perceptions of language teaching, and how in this regard does the subject English function in their English-medium schools?

The Participants

The participants of the study were pupils from P1, P3, and P5, as well as teachers of mathematics and English, that is, teachers of mathematics, teachers of English, and teachers of both subjects. Pupils' and teachers' responses and reflections were collected via interviews and surveys. Additionally, an equal number of mathematics and English lessons were observed. These data form the basis of the study.



Important Findings: Disciplinarity and Pupil Cognition in Transfer of Learning

Some important findings of the study were as follows:

1. The two disciplines were primarily perceived pragmatically and functionally by teachers and pupils. Mathematics was aligned to real-world application and English viewed as a means of communication.
2. Inter- and intra-subject boundaries were delineated and maintained during interviews by pupils and teachers.
3. Teachers were well aware of the technical language of mathematics, seeing it as distinct, context-specific, and not readily learnt outside the discipline.
4. Although a degree of metacognitive awareness was evident among pupils in interviews about mathematics, metalinguistic awareness was not as evident.
5. The teaching and learning of the metalanguage of English was evident in grammar lessons but not much in other lessons.

To understand these findings about the transfer of learning, we consider them from two perspectives: the standpoint of knowledge, the way it is conceptualised and structured as well as the standpoint of the knower or learner in terms of cognition, emotions, and identity. Thus, the two main discussion sections of this booklet are first, **disciplinarity**, and, second, pupil **cognition**. The findings and discussion lead to a section on some implications, principles, and pedagogies of transfer of knowledge and learning in Singaporean primary school classrooms.

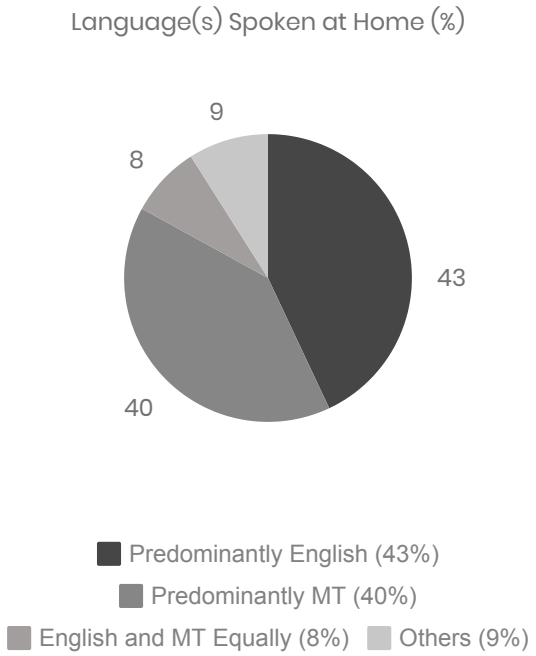
THE PARTICIPANTS

Language Profile of Pupils

The proportion of pupils who spoke English predominantly at home was found to be similar to the proportion of pupils who spoke their Mother Tongue (MT) predominantly. English is the main home language of 43%* of pupils, while for 40%, the main home language is their MT. According to pupils, 8% speak English and their MT equally, while 9% of pupils spoke mainly other languages or combinations of languages at home.

According to the Singapore General Household Survey 2015[1], English is the most frequently spoken language at home for 51% of the Chinese, Malay, and Indian resident population aged 5-14. The remaining 49% speak in other languages predominantly.

Thus, pupils' self-reported language use in our study highlights the multilingualism in Singaporean society and reminds us that almost half of the children said that they do not have a great deal of exposure to English at home.

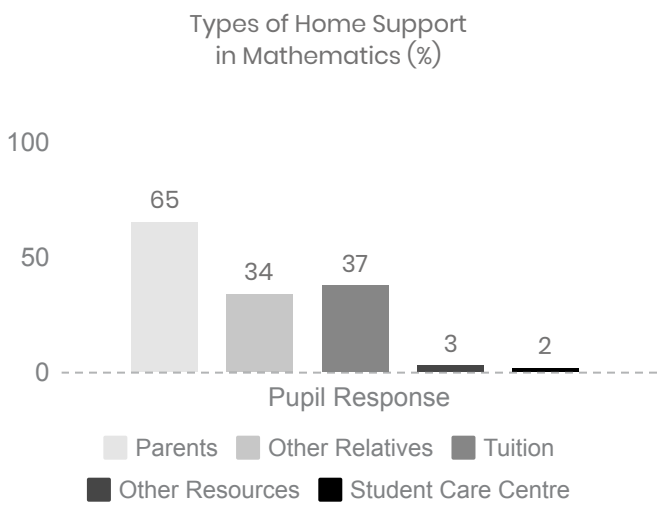


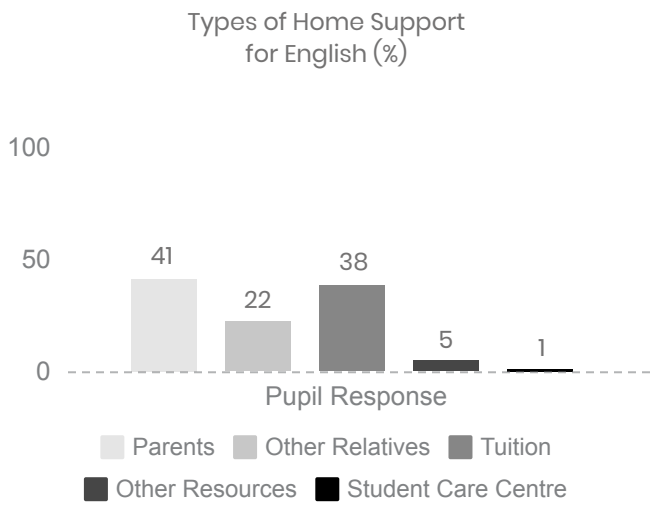
Pupils' Home Support

Pupils were asked about the type of help they received with school work outside of school.

The most common form of home support for mathematics was help from parents (65%), followed by tuition (37%) and help from other relatives (34%). Support in the form of other resources such as the Internet, as well as assistance provided in student care centres, made up a small percentage of support - 3% and 2%, respectively.

The most common form of home support for English was help from parents (41%), followed by tuition (38%) and help from other relatives (22%). Support in the form of other resources such as the Internet, as well as assistance provided in student care centres, made up a small percentage of support - 5% and 1%, respectively.





Comparing the two most common forms of support, that is, help from parents and tuition, by level, P1 pupils were found to receive the most help from their parents, but the least amount of tuition. Parental help seemed to decrease as pupils got older; conversely, the percentage of pupils with tuition was higher at P3 and P5.

Overall, pupils were found to receive more home support for mathematics than English. At P1, 60% of pupils reported receiving help from their parents with English, compared to 73% for mathematics. This difference was greater at higher levels, with 22% of pupils receiving help from their parents with English at P5, compared to 55% for mathematics.

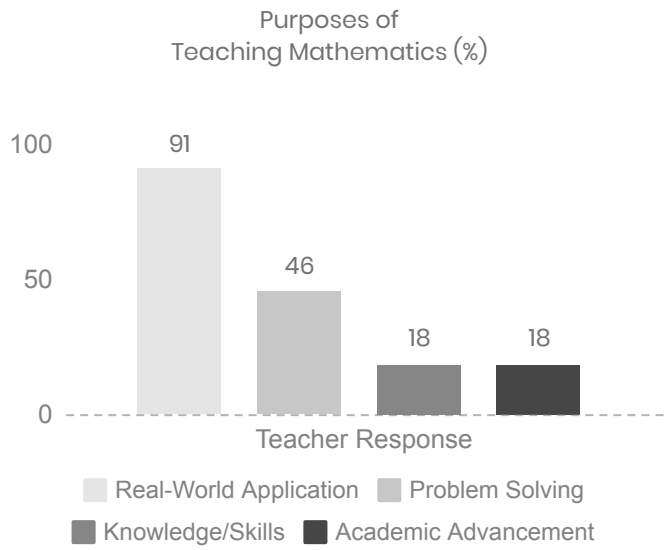
* Note: All numerical data are rounded to the nearest whole number.

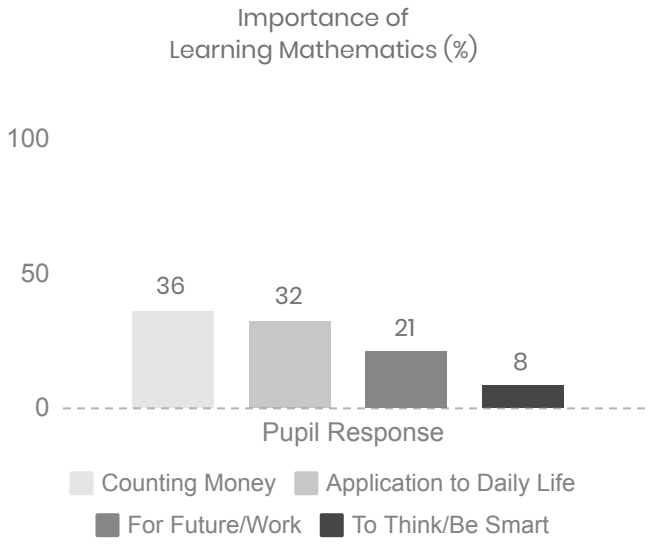
DISCIPLINARITY

The Purposes of Teaching and Learning Mathematics

Asked about the purposes of teaching mathematics, the vast majority (91%) of teachers identified real-world application as the primary purpose. Asked a similar question about the purposes of learning mathematics, pupils prioritised counting money (36%) and application of mathematics to their daily lives (32%). However, teachers' second most frequent response, problem solving (46%), was rarely mentioned by pupils as a reason for learning mathematics.

Mathematical problem solving is the central focus of the Singapore Mathematics Syllabus (2012)[2], which describes the key aims of mathematics teaching and learning as the acquisition and application of mathematical concepts and skills, the development of cognitive and metacognitive skills through a mathematical approach to problem solving, and the development of positive attitudes towards mathematics. This study finds that application is foregrounded by both teachers and pupils, while problem solving is central for almost half the teachers.





What did Teachers and Pupils Say about Mathematics?

I believe the most important thing is the problem solving.

Mathematics Teacher

I believe . . . the major part of the maths curriculum is helping pupils to be problem solvers in real life situations.

Mathematics Teacher

I think mathematics is a life skill. Nobody can survive without the math knowledge.

Mathematics Teacher

Math is useful because sometimes the things that you need to plus minus, divide all these stuff then you must know how to do . . .

P1 Pupil

It's important to learn mathematics because when you grow up you have to use money.

P3 Pupil

. . . you like need it in your . . . daily life like buying stuff, counting money, sometimes like reading time, the duration.

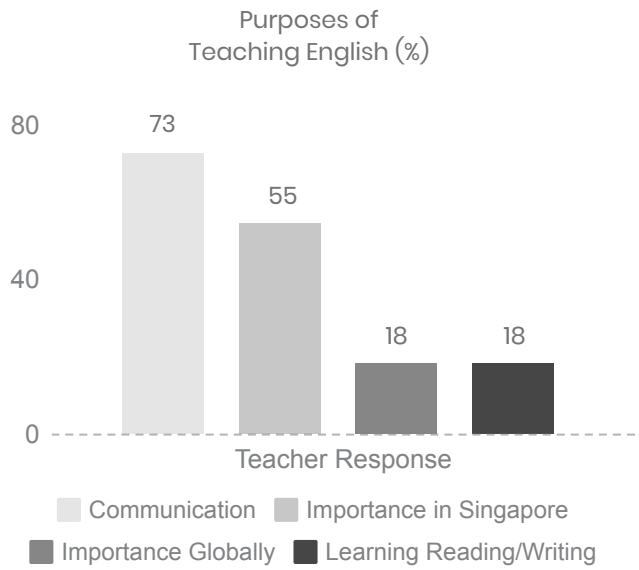
P5 Pupil

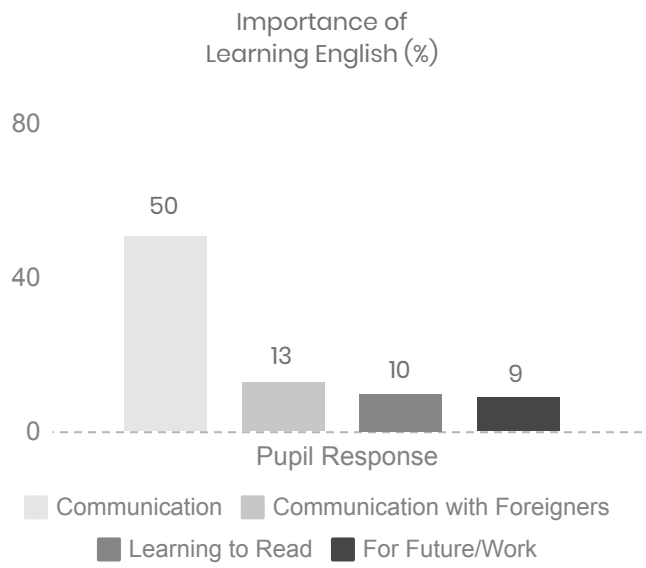
DISCIPLINARITY

The Purposes of Teaching and Learning English

Asked about the purposes of teaching English, the majority of teachers (73%) identified communication as the primary purpose. Asked a similar question about the purposes of learning English, pupils also prioritised communication as the main reason (51%). However, the second most frequent response by teachers, which acknowledged the importance of learning English for use in the Singaporean context (55%), was not reflected in pupils' responses.

Acknowledgement of the importance of English on a global level was seen in both teachers' (18%) and pupils' (13%) responses. Other reasons for teaching and learning English raised by teachers and pupils, respectively, included developing literacy skills, and the usefulness of English for future survival and employment. Thus, both teachers' and pupils' answers are aligned with the way English functions in Singapore. It is an everyday language for some and the language of the workplace for many. The role of English as an international language was recognised as well.





What did Teachers and Pupils Say about English?

Communicating effectively is definitely the main thing . . . to be able to go out and make your point known.

English Teacher

For English I believe . . . we need to have the command of language . . . and also like in our workplace.

English Teacher

. . . especially coming from the current Singapore context where English is the first language, I think we really need to teach them . . .

English Teacher

English is very important because sometimes when you want to talk to your friends you need to talk about very hard words.

P1 Pupil

. . . the boss give you some work. Give you instruction right, then don't know English, you anyhow do then bye-bye, the boss fire you.

P3 Pupil

English is a language that helps you communicate with other people from like, some countries that speak English.

P5 Pupil

DISCIPLINARITY

Teachers' and Pupils' Perceptions of the Disciplines

The two disciplines were largely conceptualised pragmatically and functionally by pupils and teachers. Mathematics was considered in terms of real-life application and English viewed as a means of communication. Thus, ideas of mathematics are aligned to the experienced world through application while ideas of English are aligned to the ordered world through use determined by language policy. The way society and education have classified each discipline seems to affect the way each is experienced and perceived by individual teachers and pupils.

The Roles of English in Singapore

In Singapore, English has a variety of functions which are in continual, albeit gradual, change, as people use languages and make language choices for themselves and their families. English was adopted as the lingua franca for inter-ethnic communication in the 1950s and 60s, being identified as unaligned to any particular ethnic group[3]. It also became the national medium of education as vernacular schools converted to teaching in English from the 70s[4]. It has always been viewed as the language of economic development[3,5] and connects contemporary Singapore internationally in industries and services such as IT, finance, education, and health. The bilingual policy describes the MT languages as those which reference values and culture for the various ethnic groups[3]. However, recent social changes in language use suggest shifts to multilingualism with English being spoken by many families although not necessarily as the dominant language. Colloquial varieties of English thrive while an affiliation to Singapore Standard English (SSE) by the middle class has also been noted.

Our study shows some of these variations in language use and affiliation among children on p. 4 of this booklet. The quotations below aptly demonstrate some children's language affiliations, their effects, and their parents concerns regarding language. Since many families now speak English as a dominant home language, the findings make us question whether the perception of language as communication is broad enough to include its important role in children's cognitive and aesthetic development in early childhood and at primary school.

What did Teachers and Pupils Say about English Language?

[English is the] way of life in Singapore. I cannot imagine if you don't have English. You can't function. I mean I guess our parents may be able to get by. But not for this generation of students.

We can't deny that home support is important. And when parents come in they will mention that, "Oh, we come from an English speaking family." But being able to speak English versus Singlish is very different.

. . . they [pupils] just use very simple words . . . probably because lack of reading, and lack of exposure . . . I understand that actually they don't speak English at home.

English and Mathematics Teachers

We only speak English [at home] because Chinese too hard . . . Chinese not speak a lot well when I was young so quite difficult.

P1 Pupil

I don't speak English at my house, with my mummy I speak a little bit English.

P1 Pupil

I usually speak Chinese with my friends, as I'm not really communicating in English well with my friends. So I prefer to talk to them in Chinese.

P5 Pupil

Pupils

DISCIPLINARITY

The Mathematics Syllabus and Teaching and Learning

The Mathematics Syllabus (2012)[2] directs that children acquire concepts and skills, develop cognitive and metacognitive thinking for mathematics, and develop positive attitudes to mathematics (p.7). The syllabus also seeks 'to influence how teachers teach and students learn', providing guidance about learning experiences as well as learning outcomes because 'ultimately how students learn matters' (p. 6).

The three principles of teaching proposed in the syllabus (p. 21) are:

1. a focus on the processes of learning: understanding, reasoning, applying, and problem solving;
2. building on knowledge and awareness of pupils' interests;
3. connecting learning to the real world, 21st Century Competencies (21CCs), and ICT.

Important for teachers, but not for pupils, was the idea of problem solving as delineated in the syllabus. Another syllabus principle, connecting to the real world, was reflected as the primary function of mathematics by both pupils and teachers in this study. However, such a dominant grounding in real world skills in the minds of pupils and teachers might overshadow the values orientation of the 21CCs.

What did Teachers and Pupils Say about Mathematics?

. . . I think the skill is useful. I mean, later in life when you want to work . . . right now also you are exposed to mathematical situation in paying, using money, or helping your mum to calculate a bit of the electrical bill, house bill, and all that.

. . . the major parts of the maths curriculum . . . whatever topics that they are learning now, it's actually part of a jigsaw puzzle, so when they grow up, they are able to combine all the skills and help them to solve problems in daily life.

Mathematics/English Teachers

Maths is important because if you don't learn money in math, you will not know how to calculate and then people might cheat your money.

P3 Pupil

. . . I think math is very useful cause can help us in our daily life like counting. Like example when you wanted to buy a house. If we see how long is the cupboard we can measure it.

P5 Pupil

Pupils

The findings show that pupils and teachers conceptualised the two disciplines of mathematics and English most immediately by their practical functions rather than as knowledge or thinking. What could the implications of this be? First, the idea of English as communication may not be broad enough to encompass the other roles of English in education such as in children's cognitive and aesthetic development. Second, the down-to-earth conceptualisation of mathematics may be obscuring the competencies of the 21st Century (21CCs) and a thinking approach to the subject. In fact, pragmatism may overshadow the potential for intellectual development and enjoyment.

Disciplinary Boundaries

Disciplines or school subjects have developed historically according to what societies count as knowledge, their traditions and practices, including their teaching and learning preferences. In education, knowledge has become classified into the subjects on the curriculum and boundaries set up between subjects to mark them off one from another[6]. Pupils and teachers in this project were well aware of subject boundaries.

DISCIPLINARITY

What did Teachers Say about Disciplinary Boundaries?

. . . even when I'm trying to explain things like quadrilaterals, they are four-sided because of the word 'quad'. You know, 'quad' means four . . . [pupils] will be like, "[Teacher], this is a math lesson, not an English lesson. Don't explain."

Mathematics Teacher

. . . I told [my students], "You can cut up 10 here and then another 10 here, ok, and then you colour them . . . What is this? 10 blue, 10 purple equals to? 20 patches." Then they say, "[Teacher], this is English, math, and a little bit of art!"

Mathematics/English Teacher

Boundaries are set and maintained between the disciplines to varying degrees of explicitness and visibility[6]. Boundaries also affect teaching and learning within the subjects. In this study in primary schools, we find that teachers and pupils not only made clear distinctions between subjects but also within subjects. Intra-subject boundaries were strongly maintained. Mathematics is structured hierarchically, so strong classification within the subject is to be expected. However, our participants created boundaries within English which is traditionally a discipline without a strong intra-subject structure. English teaching and learning materials also reflected these intra-subject demarcations. Teachers noted that schools provided books and workbooks on aspects of the curriculum such as comprehension, grammar, and assessment components, for example, synthesis. We view this tendency in the light of theory which suggests that strong boundary maintenance and a high level of technicality, including language, is likely to inhibit transfer of learning, both inter- and intra-discipline[7,8]. The mathematics teachers in this study made it clear that language specific to mathematics could not be effectively taught in other subjects, thus agreeing with the theory.

Did Teachers and Pupils Talk about Intra-Subject Boundaries?

. . . for language we've got many areas. Like there's reading, there's compre[hension], there's listening, there's speaking, there's writing, there's grammar.

English Teacher

I have difficulty on comprehension, composition.

P3 Pupil

[English] is very fun and I can learn about grammars and verbs and nouns.

P5 Pupil

. . . from whole numbers, how it moves on to fractions . . . whole numbers and fractions are not separate topics.

Mathematics Teacher

. . . fractions, decimals, whole numbers. . .

P5 Pupil

. . . to me, ratio, area of triangle, average, percentage, all of this are new to me.

P5 Pupil

DISCIPLINARITY

Approaches to Teaching and Learning in the Disciplines

Although modes of thought and therefore teaching and learning attach to each subject to varying degrees, English is traditionally a subject which attends to narrative and experience while mathematics traditionally attends to decontextualised generalisations and explanations [9]. At times, it is approaches to teaching and learning which may constrain transfer of learning [8]. Learning may be more or less segmented or cumulative. Cumulative learning enables pupils to transfer knowledge 'across contexts and through time' while segmented learning inhibits such transfer [8]. Teaching which relies overmuch on contextualisation and pupils' experience and application is likely to constrain transfer at higher levels of thinking [8]. For example, the identification of key words in mathematical problem solving and the teaching of grammar as rules and procedures, which can be applied successfully in the short term, may not be helpful with long-term transfer of deeper learning. In the case of grammar lessons where metalanguage may be taught and learnt, intra-subject boundaries between grammar and other lessons such as comprehension and composition may block transfer. However, plenty of experienced and practised examples may allow lower-order processes to transfer [10].

What did Teachers Say about Teaching and Learning in the Disciplines?

> . . . there isn't much connection made with children between levels and across topics . . . teachers fail sometimes to let children see the big picture of why they're learning something.

Mathematics Teacher

> Sometimes I try to encourage or I try to joke, or try to practise what we have learnt . . . like when we queue up, and I just throw in some points that [the pupils] have learnt earlier. Some of them, they're able to appreciate . . .

English/Mathematics Teacher

Discourse Disciplinarity

Each discipline has its own ways of using language with preferred genres, vocabulary items, symbols, interaction patterns and uses of literacy associated with the way information is presented [11,12,13]. Most importantly, the language of each discipline encodes and facilitates particular ways of thinking within the subject. Thus, those studying school subjects become members of specific discourse communities [14]. These communities are also thinking communities, as teaching and learning in the subjects develops academic knowledge and ways of thinking specific to each subject. This happens through the use of language with experts such as teachers, materials writers, and peers. Vygotsky's [15] spontaneous or everyday concepts are developed into scientific or academic knowledge through the discourses of school subjects. The discourses are, in themselves, technical and more complex than everyday language as they have to accommodate and facilitate higher-order thinking [16]. In this study, teachers were well aware of the technical language of mathematics, seeing it as distinct, context-specific, and not readily learnt outside the discipline, as the following quotations suggest.

What did Teachers Say about Discourse Disciplinarity?

> . . . for maths itself, for the sake of the maths [the pupils] are taking, they need to be good at understanding a certain style of English, not necessarily the English that they learn in the English language . . .

Mathematics/English Teacher

> . . . when you do mathematics you must have that mathematics mood where you pick up clues and things like that. It's slightly different from English.

Mathematics Teacher

DISCIPLINARITY

Disciplinary Identities

As pupils learn the disciplines and the modes of thinking and using language associated with them, they develop identities as knowers and learners of the subjects [17,18,19]. In our study, pupils constructed their identities as pupils in relation to each of the subjects and their positioning by themselves and others within it. Although an individual's knowledge of self may be erroneous, it is part of the self-knowledge that constitutes metacognitive knowledge [20]. It is, therefore, implicated in individuals' potential capacity to transfer their learning. Children mentioned personal, familial, and school factors affecting their perceptions of English and mathematics such as:

- being good at the subject
- family talent
- available resources
- cognitive challenge (most often with regard to mathematics)
- familiarity (most often with regard to English)
- confusions and memorability
- experiences of learning (mathematics as a thinking subject, and English as a wordy subject full of rules)

How did Pupils Construct their Disciplinary Identities?

I like Math because Maths is about plus or minus then I know how to do everything.

[I prefer] English . . . because I always speak English most of the time . . . It help me in some of the question in math and science.

Math is more difficult than English and like I said, I love challenge.

. . . Mathematics makes me good. Because I don't know mathematics . . . so I learn mathematics.

I think [English is] quite boring because you just repeat the same thing like grammar and grammar and grammar.

I like English because English got less concept. But then math right, you have to understand this strategy, that strategy. . .

P1 Pupils

P3 Pupils

P5 Pupils

Diversity

Teachers viewed the learning identities of their pupils in terms of diversity, including home language, home support, tuition, family resources, subject preference, talent in the subject (conceptualised as ability), willingness to talk, and learning gaps. These considerations triggered the teaching dilemma of how to accommodate the cognitive, emotional, and social needs of individual children most effectively.

I suppose for pupils who . . . speak primarily English at home, they would have lesser difficulty understanding what the question means.

. . . Usually the better ability classes, the parents are very involved.

. . . we do experience students who have tuition, and they will be like, oh my tuition teacher has gone through this already.

Mathematics Teacher

English Teacher

Mathematics Teacher

COGNITION

Metacognition

Having considered the structuring of knowledge in the disciplines in relation to transfer of learning, we now focus on the pupils as knowers and learners. Researchers suggest that metacognition or higher-level thinking facilitates pupils' capacity to transfer and adapt their learning flexibly across contexts and over time and tasks [21,22]. Metacognition has been found to be strongly related to performance in mathematics, more so than general intelligence [23]. Metacognitive development is an aspect of children's general cognitive development. Whether and how it might develop has been linked to age, family socio-economic status, and home language [24] as well as schooling [15]. Our study suggests that older children were more metacognitively aware. This could be related to age, general maturity, or instruction in school.

Metacognitive Awareness and Skills

Metacognition is fundamentally a conscious control of thinking. It is generally conceptualised as both metacognitive knowledge or awareness and metacognitive skills. Metacognitive awareness works at the level of consciousness. It includes knowledge about self as well as the discipline, while metacognitive skills include both procedural, that is, knowing how to apply higher-order thinking skills, and conditional, that is, knowing in what circumstances to apply them. These skills assist pupils in goal setting, planning, controlling, monitoring, and regulating their performance on tasks [23]. Pupils in the study most often described their learning strategies as having to do with memory and practice. Other strategies they reported using were asking parents and other family members, friends, and teachers. However, some, demonstrating a higher level of awareness, described their own thinking processes, for example, visualising. Overall, there was more direct attention to learning strategies in mathematics than English.

What did Pupils Say about their Learning Strategies?

Practice. Practice at home more and more.

P1 Pupil

I will first try . . . if very the tricky problems, I will just ask my teacher, how to do it and how to do the model like this.

P3 Pupil

I draw a model so I can see, like, visualise what is really happening.

P5 Pupil

What did Teachers Say about Pupils' Learning Strategies?

. . . By drawing the model, there is a visual for them to see. And with the visual . . . you can see and make out whether your understanding is correct or not, I would say.

I think sometimes in school, there's only so much that the teacher can keep telling . . . after that, the reading, the coding and vocab, [the pupils] need to do it on their own.

. . . if [pupils are] really exams-oriented, to them, they have to practice a lot. Which is quite true to a certain extent but . . . if they don't learn the correct skills, no matter how they try to practice it will up with nothing.

Mathematics Teachers

[Parents give pupils] assessment books . . . I don't think that's good. Because your child will be so prepared, they know so much, they will not be interested in your lesson.

English Teachers

COGNITION

Explicit Teaching and Exploratory Talk for Metacognitive Development

Fortunately, research in both English and mathematics shows that metacognitive awareness and skills can be taught and learnt in school [25,26,27,28]. It takes time to construct deep, transferrable understandings and researchers and educators suggest that explicit teaching is necessary [22]. This is not teaching which merely presents rules and procedures to pupils; on the contrary, it involves teaching the metalanguage or discourse of the discipline, and guiding pupils in actively constructing and articulating understandings through exploratory talk [29,30] through effective teacher explanations and metatalk. These aspects of teaching and learning have been shown to be effective in developing metacognition in both mathematics and English [31,32,33,34].

The conversation-rich and explicit teaching is thought to be especially effective in developing metacognition among low-performing pupils [23] as well as kindergarteners [32]. Girls too would benefit because girls with the equivalent metacognitive knowledge to boys appear to be unable to operationalise that knowledge in the process of mathematical problem solving [18,23]. In fact, a strong theme emerging in the pupils' discussion about their learning processes in both subjects was the high value they placed on effective explanations whether these were offered by teachers, tuition teachers, parents, friends, or siblings.

What Did Pupils Say about Explaining?

[The teacher explains things] two or three times . . . if somebody like, don't understand she will repeat more times.

P1 Pupil

If someone explain to you at school . . . if [exams or mini tests] come out with the similar question, you know how to do.

P3 Pupil

My mum teaches me for my maths . . . if the answer that I get is wrong, then she just teach me step by step.

P5 Pupil

My tuition teacher, when we're doing the workbook she will tell us the understanding of the word problems.

P5 Pupil

Pupils

When we don't understand, [our teacher] can go through . . . until we understand, so that we can get used to it.

P5 Pupil

Pupils

I don't know how to explain. My tuition teacher teach me.

P5 Pupil

Pupils

Both the mathematics and English syllabi highlight the need to teach pupils to become metacognitively aware and skilful in applying higher-order thinking processes appropriately and effectively. This study finds varying degrees of metacognitive awareness and reported skills among pupils in both subjects. The exploratory nature of the study, however, meant that we were unable to link metacognition to any of the factors suggested by other research.

Metalinguistic Awareness

Another aspect of children's development as thinkers related to metacognition is the development of metalinguistic awareness. Children's development of thinking occurs through language with scientific concepts and language developing at the same time as schooling [16]. Learning to read in itself encourages children to become aware of language not only as a communicative tool but also as a system from which they can make choices for effect and precision. One definition of metalinguistic awareness is 'the ability to reflect on and manipulate the structural features of language' (p. 1) [35]. Metalinguistic knowledge has been conceptualised as analysis of knowledge, that is, 'the ability to construct explicit representations of linguistic knowledge' and control of processes, that is, 'intentionally selecting and applying knowledge to arrive at a solution' (p. 155) [36]. This study finds that although a degree of metacognitive awareness was evident among pupils in interviews about mathematics, metalinguistic awareness was not as evident.

COGNITION

Metalinguistic Awareness and Reading

If, as research suggests, reading is deeply implicated in the development of metalinguistic awareness, the findings of this study are of concern. Teachers noted that their pupils were not habitual readers, that many did not enjoy reading, and that tuition and other occupations may be taking over their reading time. As well as affording pleasure, reading is a route into experience of the world which is coded in English. It is important to consider that many multilingual pupils in Singapore are learning general knowledge and experience in English at the same time as they are expected to draw on this knowledge to read in other subjects. Considering that much of the teaching of mathematics uses word problems intended to reflect real-world situations, developing a reading habit in English is extremely important for the early stages of mathematical study. Furthermore, teachers noted that some pupils in P1 could not read word problems. Thus, for some children, understanding in mathematics is linked to language development. This was a dilemma raised by teachers.

. . . [pupils] need to be able to comprehend. To make sense of what they're reading. So if their language is not good then will they be able to understand what the question is saying?

English Teacher

I feel that, reading [is a difficulty] . . . numbers, like two plus three, we give them sums like that, drills, they could do it . . . but once you give them words . . . I feel that there is some resistance to do that question.

Mathematics Teacher

Metalinguistic Awareness and Vocabulary

Metalinguistic awareness has usually been studied in the different aspects of language, for example, phonology, words, syntax, and pragmatics. However, more recent work [37] shows the interrelatedness of the development of vocabulary and reading with metalinguistic awareness. Similarly, children have been shown to write more effectively when making intentional grammatical choices [38]. Nevertheless, one area of metalinguistic knowledge very audible in pupils' responses was that of vocabulary. At lower levels, they were concerned with pronunciation and spelling and said that when they had difficulty with homework it was often to do with unknown words in English and mathematics. Teachers also highlighted the need to teach vocabulary in both disciplines. This finding can be explained with reference to input theory [39]. Access or exposure to language input in huge amounts is crucial for linguistic and associated cognitive development. If children do not experience English at home, and neither do they read much, the learning gaps noted by teachers are a potential result. However, input by itself is not sufficient for learning, and neither is practice; more importantly, children also need to articulate their understandings, allowing metalinguistic awareness to develop [40].

Sometimes [English is] difficult because some of the words we haven't learnt yet.

P1 Pupil

I know how to spell the words but I don't know how, what's the meaning of the word.

P3 Pupil

Sometimes I don't understand the vocabulary it's because it's like new words popping up every second.

P5 Pupil

COGNITION

Metalinguistic Awareness and Multilingualism

Recent research shows that multilingual children have little advantage in knowledge about language or analysis of knowledge over monolingual children. Importantly, however, bilingual children seem to be able to control processing on metalinguistic tasks very much more effectively [41]. This ability is central to higher-order thinking. With regard to metalinguistic knowledge in mathematics, dominant English bilinguals are seen to have an advantage in self-correcting language errors when solving mathematical problems [42].

Metalinguistic awareness is particularly helpful to bilingual children who are learning to read in a language different from the one they most commonly speak [35]. When children are aware of the similarities and differences among the languages they are learning, they may find the task easier. It is the youngest, least advantaged [35], and those who speak the languages most different from English that would be most assisted by a contrastive linguistics pedagogic approach [43,44]. This may involve teacher and pupil discussion, which focuses on language itself and how it looks and works differently across languages and varieties. The principle of contrastive linguistics may also apply across disciplines where similar linguistic forms have different functions, for example, English and mathematics.

Metalinguistic and Metacognitive Awareness

It seems likely that metalinguistic awareness is implicated in the development of metacognitive awareness. However, neither the English or mathematics syllabi focus on children's metalinguistic awareness. The study findings show that despite teachers' awareness of the technical language of mathematics and the teaching of English grammatical metalanguage in the observed lessons, and although some pupils acknowledged the importance of language in learning mathematics; in many cases, their expression was impressionistic. Interviews over P1, P3, and P5 show that this vagueness about metalinguistic knowledge is unrelated to age.

How Aware were Pupils about their Thinking and Language?

. . . maths questions there is English words and for our English ones also we have maths numbers.

I may find something difficult when I don't understand the question.

Look around. Think everything mathematically . . . That's what I do whenever I walk.

I have to learn more English . . . because at least I can explain more for mathematics.

If we don't know English then we can't talk math.

. . . if there's like, a question without any words you don't know what is it talking about so you can't do it.

. . . sometime when I don't know how to read the word my mother will teach me how to read then I will do by myself. Then I can do.

If there are numbers and important words, you just circle or underline them so that you will know . . .

My tuition teacher taught me that, uh, the sensory word must be, must add -ing.

P1 Pupils

P3 Pupils

P5 Pupils

IMPLICATIONS FOR CLASSROOMS

Transfer of Learning: Principles and Pedagogies

In conclusion, we encapsulate the implications of the study into some principles and pedagogies which will help us enable children to transfer their learning over time within a school subject, such as grammatical knowledge to writing, across school subjects, such as English to mathematics, and across locations, such as home to school.

1 Disciplines

On the one hand, the way we perceive the knowledge of a subject can limit its potential transferability, especially when we create and maintain strong boundaries between subjects. However, on the other hand, particular approaches to teaching and learning may encourage transferability. Disciplinarity and pedagogy therefore may be combined and balanced to achieve the most positive transfer effects.

2 Identities

As pupils learn a school subject, they learn ways of using language and ways of thinking, some of which are highly subject specific. They also construct identities in relation to the subject. Their learning experiences at home and at school affect how they perceive the subject and themselves. These resulting self-perceptions and views on the subject affect their present and future learning.

3 Metacognition and Metalinguistic Awareness

Metacognitive and metalinguistic awareness in children appear to be necessary in enabling the transfer of sophisticated learning. Additionally, the development of metalinguistic awareness might be a necessary aspect of metacognitive awareness. We should therefore give as much attention in policy and pedagogy to developing children's metalinguistic awareness in all subjects as we currently do to encourage their metacognitive awareness.

4 Reading

In general, learning to read cannot be achieved without a degree of metacognitive and metalinguistic awareness, such as the awareness of sounds or phonological awareness. Learning the process of reading also develops higher-order cognition. However, in particular, reading skills are somewhat discipline specific, so they should be explicitly taught in each subject as well as in English lessons.

5 Talk

Talk about learning encourages metacognitive and metalinguistic awareness. It is important, therefore, to allow space in lessons for exploratory talk through which pupils may articulate their own understandings and teachers may give feedback to scaffold learning. Pupils found good explanations to be critical in their learning, so we should examine what constitutes good explanations for diverse pupils at varied stages of learning. Equally, we should teach listening skills explicitly to enable pupils to access teacher explanations.

6 Multilingualism

In Singapore's multilingual context, many children in primary school learn to speak English at the same time as they have to learn to read and write it in all subjects. Their bilingualism is an advantage in helping them control their performance on metalinguistic tasks. However, we should be mindful that, in addition to wide reading, school may be their only source of academic language input. We must remember too that when experiential teaching methods are used, for example. word problems in mathematics, pupils may only just be learning knowledge of the world coded in English.

IMPLICATIONS FOR CLASSROOMS

Pedagogies to Enable and Enhance Metacognition, Metalinguistic Awareness, and Transfer

We propose using pedagogies which encourage a thoughtful, interested approach to teaching and learning to enable pupils to transfer their learning over time and across contexts and tasks:

- a **contrastive pedagogic approach** through which the differences and similarities among languages and subject disciplines are highlighted could be efficient and effective as it would appeal to bilingual children's cognitive advantage and compensate for their relatively lower exposure to language as input;
- attention to **explaining** as well as to 'doing' through demonstration and practice, that is, using **metatalk** to **teach explicitly**;
- pedagogies to teach **grammar as concepts**, aiming to develop mental flexibility in pupils, in addition to pedagogies to teach **grammatical metalanguage**;
- a whole school pedagogic approach to developing **extensive reading** so children have access to language input of an academic variety as well as knowledge of the world coded in English;
- pedagogies to teach vocabulary as **word consciousness**, in addition to pedagogies to teach the skills of inferring meaning in context, aiming to enable pupils to generalise knowledge of vocabulary patterns to novel contexts;
- pedagogies to provide pupils with opportunities for **exploratory talk** for problem solving and to scaffold the learning of exploratory talk through **teacher-guided reporting and feedback**;
- the pedagogic strategy of **rewording** in mathematics, with the aim of teaching children to manipulate language and understand, e.g. the contexts of mathematical word problems;
- the pedagogic strategy of **annotating**, with the aim of teaching children to notice language and linguistic relationships;
- pedagogies of **beginning reading**, e.g. techniques such as pointing, phonics, and choral reading in the subject lessons as well as in English lessons, with the aim of bridging the gap in understanding content for beginning readers;
- pedagogies to teach the **discipline-specific technical language and reading skills** in the disciplines themselves.

Further Research in Classrooms Useful for Improving Teaching and Learning Experiences

By examining teacher and pupil perceptions and experiences of teaching and learning in the subjects of English and mathematics, this exploratory study has produced insights into the education process at P1, P3, and P5. It has highlighted connections and relations between pupils' constructions of identities, teaching dilemmas, language and thinking, and disciplinarity. The findings suggest areas for further research which could be invaluable in improving teaching and learning experiences.

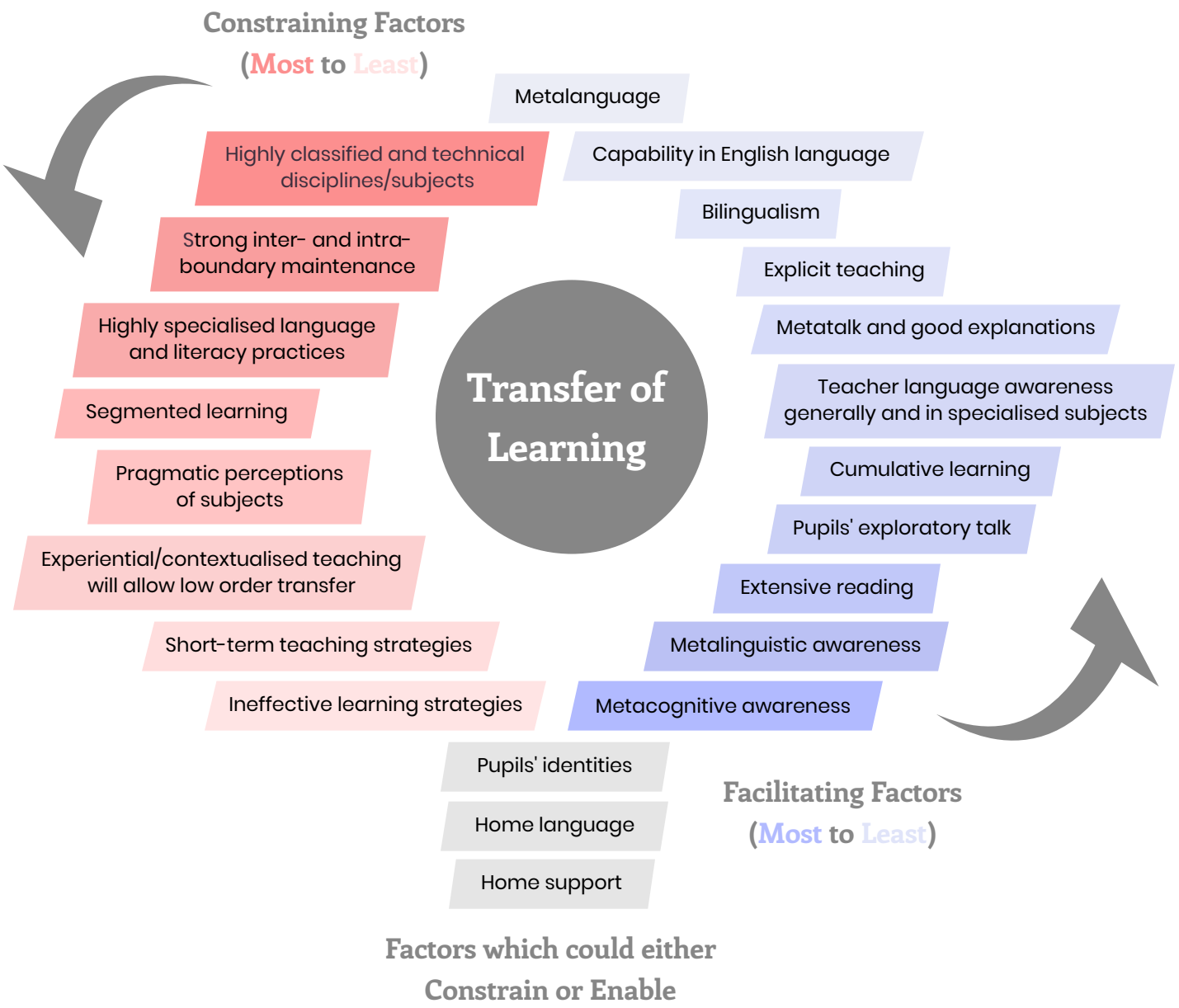
1. Research into classroom language interaction and the ways in which it is related to children's intellectual (metacognitive, metalinguistic, transfer) and language development. Useful areas of focus might be metatalk, explanations, and explicit teaching, as well as teacher language awareness.
2. Research seeking to study the development of metacognition and how far it results from general maturation, schooling and instruction, and/or learning to read.
3. Deeper research into the factors involved in diverse pupils' identity construction as it affects their development and learning, aiming to identity some factors which are more likely to be modified with interventions.
4. Research interventions to teach grammar and vocabulary applying a conceptual approach.
5. Benchmark research into the teaching of listening and speaking in English lessons, with particular attention to exploratory talk.
6. Research interventions to teach discipline-specific reading and/or vocabulary in mathematics lessons.

CONCLUSION

Conclusions about Transfer of Learning

Finally, one of our research questions asked how far the language taught in English might be transferrable to mathematics lessons. Our findings show a much more complex picture than we first hypothesised, showing many interrelated factors to do with pupils' and teachers' experiences and perceptions about mathematics and English (also the topics of research questions of booklets 1 and 2 of this series). We present a diagram to illustrate some constraining and enabling factors implicated in pupils' ability to transfer learning to fresh contexts over time which emerged from our study.

Our study and review of the literature suggests a 'most to least' ranking of the factors, but it is likely that this ranking will vary according to context. Additionally, some highly influential factors may be either constraining or enabling such as pupils' identities, home language, and home support.



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