

Children's ability to interpret metaphorical polysemy in educational materials

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Metaphor is used as a tool for communicating specialist knowledge to non-specialists in popular discourse and in educational contexts. Research has explored its use in higher education, but less is known about its efficacy with learners of school age. Experimental research has shown that very young children are able to interpret and produce attributional metaphors, but that relational metaphors and analogies do not seem to be understood until late childhood. The qualitative study reported here complements that work. We interviewed 30 children aged between 10 and 12 in focus groups, eliciting instances of academic words and meanings that they found new and challenging, and using naturally-occurring educational texts as prompts for discussion about individual words. We found some awareness of polysemy in general, and of word meanings that have a metaphorical basis. However, when they encountered a new metaphor-related meaning of a known word, the children showed a tendency to fall back on the previously known meaning even where this was contextually unfeasible. When specifically asked to work out the new meanings, it became evident that this is often challenging for them even with scaffolding.

Keywords: metaphor, polysemy, children, school language

1. Introduction

Metaphor has often been talked of as a pedagogic device. This extract, from a website for school teachers, offers an attractive rationale:

We make sense of new information by forging connections to something we already know [...] Understanding existing ideas and creating new ones rely on recognizing and comparing similarities and differences across concepts– in other words, on making connections. (Hume, 2011)

However, there is relatively little research into how much metaphor children encounter in school and whether it genuinely does support their learning. What is known is that the academic language of school contains many examples of polysemy, specifically, words used with specialist meanings that are different from their everyday meanings (Quigley, 2019; Fang, 2006). The number of these specialist meanings has been found to increase a good deal as the discourse of school becomes increasingly discipline-specific (Deignan et al., 2023). In England, the context of our study, as in many other contexts, this happens as children move from primary schools where much teaching is undertaken by a generalist class teacher, to secondary school, where the different subjects are taught by disciplinary specialists, at around the age of 11. Given that much polysemy is metaphorical in origin (Moon, 1986), it seems likely that school students may encounter a good deal of new metaphorical language in school, and that this probably increases sharply as they begin secondary school.

In an attempt to untangle the related issues of polysemy and metaphor in school language, and school children's comprehension, we investigated the following research question:

What difficulties, if any, do 10–12-year-old children in England have with the vocabulary of school when it involves:

1. polysemy generally, or
2. metaphor-based polysemy specifically?

2. Literature review

2.1 Metaphors as pedagogical tools

Boyd (1993) made a well-known distinction between theory-constitutive and pedagogical metaphors. Theory-constitutive metaphors push scientific and other kinds of knowledge forwards, offering insights generated through analogy with known source domains, while pedagogic metaphors are used to communicate established specialist knowledge to non-experts. Knudsen (2003) analysed scientists' theory-constitutive use of metaphor to explore new ideas and compared this with use in popular explanations for non-scientists, finding that while the functions of metaphors are different for different audiences, often the same or very similar metaphors are used.

Low (2008) summarised research supporting the use of metaphor in higher education, listing advantages including the development of learners' abilities to use analogy more widely, the possibilities of visualising academic concepts, and

allowing for hypothesis generation and testing. More recently, Smedinga et al. (2023: 255) wrote:

... laypeople—who lack relevant scientific education and experience— will often need to borrow alternative tools for understanding from domains with which they are familiar, such as everyday life. For example, those who are familiar with the mechanism of a greenhouse can use this as a model for understanding the causes of global warming.

They also claim that experts' use of metaphor with the public does not simply convey knowledge but enhances reasoning skills, in other words, has an important pedagogic role.

There is thus a consensus that metaphor is a widely used and effective tool for conveying scientific understanding to non-expert adults. However, it cannot be assumed that this usefulness extends to children and adolescents. One study found that students aged 11–15 frequently over-generalised from metaphors, resulting in somewhat inaccurate accounts of the science they had studied (Deignan et al., 2019).

2.2 Children's ability to understand and produce polysemy and metaphor

That metaphor is a central driver in generating new meanings of words is agreed by cognitive linguists such as Gibbs (2017) and corpus lexicographers such as Hanks (2013). Metaphor identification procedures such as MIP (Pragglejaz, 2007), MIPVU (Steen et al., 2019) and Vehicle identification (Cameron, 2003) are based on the premise that a lexical unit in text has other available meanings—that is, it is polysemous. It follows that to interpret a metaphorical meaning of a previously known word, children need to have some ability to deal with polysemy. Children's talk shows some use of different meanings of the same words from as young as 2 (Werkmann Horvat et al., 2024), but research with primary school aged children also suggests that they sometimes struggle to learn new senses of polysemous words, and that the known meaning can interfere with learning the new meaning (Booton et al. 2022a). Ability to identify polysemy and match senses of polysemous words improves consistently between age 5 and 9 (Booton et al. 2022a, 2022b).

The word senses that children are most likely to correctly identify are those that are the most frequent in texts they have accessed, and the most imageable (Booton et al. 2022b). The quality of imageability seems to overlap with concreteness, meaning that many academic senses of words have low imageability. For instance, Booton et al. (2022b) illustrate imageability with the “bicycle” sense of *cycle*, which is imageable in contrast with the “recurring process” sense.

The ability to understand both conventional and novel metaphors develops throughout the school years (Nippold, 2006) and into adulthood (Rundblad & Annaz, 2010). Differences in comprehension have been established between participants aged 11 and 15, and between aged 15 and 21 (Carriedo et al., 2016). Many idioms that seem straightforward to adults are difficult for adolescents; for instance, Nippold and Taylor (2002) found that 16-year-olds struggled with *turn back the clock*, *take someone under one's wing*, and *take someone for a ride*. Willinger et al. (2019) found improvements across their sample of 7, 9 and 11-year-olds, positing a qualitative difference in the 11-year-olds. They found that by the age of 11–12, children are often able to explain links between the topic and vehicle of a metaphor.

Hessel and Murphy (2019) found improvement in metaphor comprehension between children in Year 1 (aged 5–6) and Year 2 (aged 6–7) in schools in England. However, Deckert et al.'s (2019) study of 7–10-year-olds found variation within even typically developing children operating in their first language.

There is a developmental shift in the type of metaphorical relationships that are understood and used. Very young children, aged 2–3, appear to produce metaphors in which the comparison between topic and vehicle is based on physical attributes. For instance, Gentner (1988) gives the example of a 2-year-old child comparing a crescent moon to a banana: here, the relationship between the vehicle, *a banana*, and the topic, *a crescent moon*, is based solely on shape. In contrast, metaphors involving relational structure such as “a tire is a shoe” [for a car] (Gentner, 1988: 3), are produced and understood later (Gentner, 1988; Winner et al., 1976).

An important difference between many of these studies and our context is which aspect of metaphoricity is new to the child participants, and thus tested for. Some experimental studies test for the ability to construct a novel connection between two entities that the child participants will already know, such as *honey* and *lemon* in “your honey tastes like a lemon” (Carriedo et al., 2016). Similarly, in Deckert et al.'s (2019) study, children were tested on their ability to construct meaningful metaphorical connections between known entities. The researchers presented participants with triads of entities, such as “fish/ winding river/ snake”, and “grandfather/ rocking chair/ ancient tree”, each of which contained two items that could be metaphorically related. Children were asked to find and explain meaningful pairings in each triad, and were scored for identifying and for explaining the metaphorical pairing. In each of these studies, the potential source and target domains are well known to participants. Our context differs in that it concerns specialised academic target domains from the school curriculum but probably not yet known to the children. On the other hand, the metaphors them-

selves are generally conventional within the subject discipline, not requiring novel mapping, at least by adult standards.

2.3 Pedagogical metaphors and children

There is less research on the use of pedagogical metaphors in school contexts than in higher education or popular texts, though “educators appear to believe that students can import conceptual relations and operations from one domain to another” (Gentner & Gentner, 1983:100). Science teachers were found to be enthusiastic when introduced to the potential of metaphorical mapping to explain difficult abstract topics such as energy (Daane et al., 2018). Gentner & Gentner (1983) explored two metaphors for electricity: a flow of liquid and crowds of people, with high school and older students, and found that the analogical conclusions supported by each metaphor were borne out, in the cases where their participants used the analogies consistently.

Cameron (2002, 2003) studied 9–11-year-olds in primary school classrooms in England. She notes three issues with the use of metaphor in teaching (2002: 676). Firstly, children may not understand that what they hear or read is metaphorical at all; that is, they may force a literal interpretation on a metaphorically-used word. Secondly, Cameron notes that they need to be familiar with the source domain, giving the example of *shield*: “a child who knows nothing about shields will not be much helped by its application to the atmosphere” (ibid). Finally, she points out that for a metaphor to be successful, children need to map appropriate attributes from source to target domains. In Deignan et al.’s data (2019), some children and adolescents incorrectly mapped the physical structure of a greenhouse onto the Earth’s atmosphere, talking about there being a thin, glass-like shell around the Earth, rather than mapping the process by which glass allows heat in but not out.

Cameron’s (2002, 2003) findings around metaphor comprehension are based on a detailed series of interviews with two girls in Year 5 in England (aged 9–10), part of a wider ranging study of metaphor in educational discourse. With the exception of Cameron’s work, research into children’s understanding of polysemy and metaphor is largely experimental. Our study complements this body of work, through semi-structured interviews with 30 children, and focuses on naturally-occurring language use in the academic school context, thereby increasing the ecological validity of our study.

3. Method

3.1 Interview data

The data are 15 semi-structured focus group interviews, which were conducted on school premises by the second author. These formed part of the data collection in a larger project, which aimed to identify language that children find challenging when they move from primary school to secondary. In the interviews, the children were asked about their thoughts about this transition, their academic experience and expectations, and particularly about the language of school. The interview questions were developed in consultation with a secondary school teacher at one of the participating schools, whose role includes supporting the transition from primary schools. The schedules are in Appendix A. The teacher-advisor recommended several prompt texts to discuss with the children, which he or his colleagues had used with children this age. These formed the basis of some of the discussions about word meanings.

At the start of the data collection, the children attended 5 different primary schools in different parts of Yorkshire and Northumberland, in Northern England. We asked each of their 5 class teachers to select 6 children to form a group that while typically-developing, represented a range of abilities and backgrounds, and equal gender distribution. The children were interviewed in their groups twice in their final year of primary school (Year 6), in March and June 2019, in school time, in a room provided by their schools. They left primary school in July 2019 and started secondary school in September 2019. The 5 primary schools “feed” 3 secondary schools, thus 8 schools are involved in total, as shown in Figure 1, which uses pseudonyms for the schools to protect identities. None of the schools is selective or fee-paying. Once the children started secondary school, the children from each original primary school class were dispersed across different classes, but the secondary schools facilitated them meeting again in their original groupings, in school time, for a third interview in October 2019. To summarise, 30 children were interviewed in total, in the same 5 groups, on 3 separate occasions. Across the 15 group interviews, there were 2 absences, both in the second round. During the first two rounds of interviews the children were aged 10 and 11, and in the third round, 11 and 12.

Ethical approval was granted by the University of Leeds, UK, and the parents or guardians of the children gave signed informed consent twice, before the first and third rounds of interviews, covering all the interview rounds. The children themselves gave written assent before the interviews.

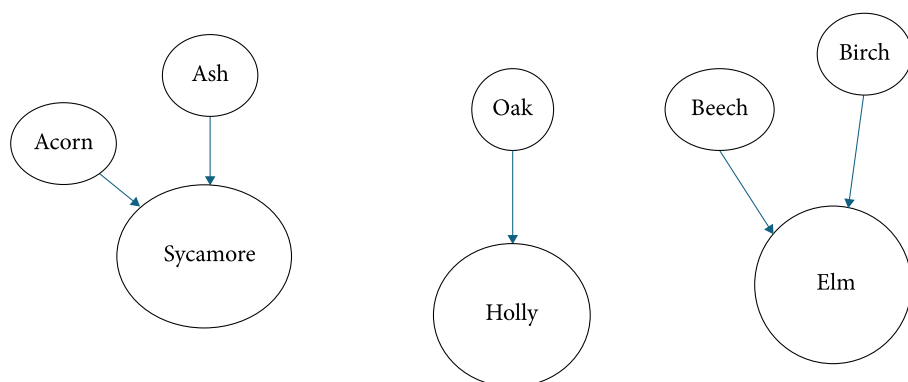


Figure 1. 5 primary schools which feed 3 secondary schools

The data were transcribed by two research assistants, who were supervised by the second author. The first author checked the transcripts, listening to all of the audio files. The average interview length was 52 minutes 44 seconds. The shortest was 48 minutes 2 seconds, the longest was 58 minutes 35 seconds. The average transcript was 7594 words. The shortest transcript was 5100 words, and the longest 12010 words. The longest transcript was around 2500 words longer than the second longest; on checking this was found to be the result of the children talking over each other to an unusual degree. With this transcript excluded, the average length was 7278 words. Tables 1, 2 and 3 give details. All children were given equal opportunity to respond to every question during the focus group, with the interaction managed using names and body language, by the interviewer. As is common in many focus group settings, we acknowledge that there may have been social alignment effects **within** each group, whereby children may have felt pressure to respond in line with their peers. However, **between** the five groups there was no contact whatsoever for the first two interviews, and very limited possibilities for contact for the third (when two pairs of groups attended the same secondary school).

Table 1. Interview Round 1, March 2019, Primary school

Group, interview	School name*	Number of children	Duration	Tokens
Group 1, Int 1	Acorn	6	49.09	6478
Group 2, Int 1	Ash	6	57.05	12010
Group 3, Int 1	Oak	6	52.26	8465
Group 4, Int 1	Beech	6	45.31	5100
Group 5, Int 1	Birch	6	51.08	6359

* pseudonyms

Table 2. Interview Round 2, June 2019, Primary school

Group, interview	School name	Number of children	Duration	Tokens
Group 1, Int 2	Acorn	6	57.16	7380
Group 2, Int 2	Ash	5	46.25	7356
Group 3, Int 2	Oak	5	52.47	7691
Group 4, Int 2	Beech	6	55.17	8785
Group 5, Int 2	Birch	6	55.56	7584

Table 3. Interview Round 3, October, after move to secondary school

Group, interview	School name*	Previous primary	Number of children	Duration	Tokens
Group 1, Int 3	Sycamore	Acorn	6	54.26	7608
Group 2, Int 3	Sycamore	Ash	6	58.35	9551
Group 3, Int 3	Holly	Oak	6	55.58	7140
Group 4, Int 3	Elm	Beech	6	48.02	6461
Group 5, Int 3	Elm	Birch	6	53.33	5939

* pseudonyms

The interview transcripts are available through the UK Data Service in the Reshare repository: <https://reshare.ukdataservice.ac.uk/856447/>.

3.2 Procedure: Coding and themes

A reflexive thematic analysis (RTA) (Braun & Clarke, 2021; Byrne, 2022) on the 15 interview transcripts was carried out by the first author, using NVivo version 14 (QSR International Pty Ltd, 2020), which allows for multiple and iterative coding. To do this, the whole dataset was read through three times, including once while listening to the audio files. Coding was carried out and/ or reconsidered on each reading. Sections of particular interest were then re-read in more detail. The data were manually coded for all mentions by the interviewees of the language of school, and all instances where there was any mention of an issue with language generally, or a specific language item. Given the nature of the interview questions, this often came up when there were problems with school language, or when the researcher asked the children for their understandings of the prompt texts. The third author read a sample of the interviews and commented on the first author's coding. Their comments were discussed, seeking "richer interpretations of meaning", as Byrne (2022: 1393) characterises the role of co-researchers in an RTA. It

should be emphasised that we did not undertake a metaphor analysis of the entire transcripts. Our goal was not to identify metaphor use in the children's talk or in educational texts. Rather, we sought to find out the lexical items that they noted as new, interesting or problematic, and to examine their explanations of meanings, either spontaneous or in response to the prompt texts. For example, several interview groups discussed the word *volume*, as used in mathematics, saying it was "confusing", as in this extract:

Interview extract 1 Beech school

George	oh that word <i>volume</i> , that's confusing
Researcher	Why is it confusing to you?
George	Because <i>volume</i> 's like on a TV or something
Researcher	that you turn up and down
George	Not like in shapes

We followed Braun & Clarke's (2021) principles, and were also informed by Byrne's (2022) worked example. This meant that the codes were not specified in advance but were identified through iterative reading of the data, and were led by what the participants themselves said, and not by a predetermined framework. In this way, we arrived at the following top level codes:

Difficult words

Genre and register

Polysemy

Synonymy

Definitions/explanations

The children made no mention of metaphorical relationships between meanings either directly or indirectly, so "metaphor" was not used as a code. Interview extracts could be coded to more than one category, but in fact this was rare. In one of the few examples, a short discussion about new words in geography which included *climate* was coded for "synonymy" as well as for "difficult words", because the children commented that it was difficult, and also that they thought it was a synonym for the everyday word *weather*.

The extracts coded "difficult words" occurred in conversations where the researcher asked about the language of school, and children used "hard" or "difficult" to describe a word. 54 words in total were coded as difficult on the basis of the children's mentions or problems in explaining their meaning in context. Many of these were mentioned by more than one interview group (reflecting the shared

curriculum they follow). The majority were technical terms such as *alliteration*, *arachnid*, *magma* and *pollination*. As would be expected, children frequently said that they had encountered difficult words but could not remember them. Of the difficult words, seven words were also coded “polysemy”, because they had other meanings that the children knew and, apart from *net*, remarked on:

capital, mean, net, product, significant, static, volume

A number of words in the prompt texts that had been provided by the teacher-advisor gave rise to discussions which we coded “polysemy”. (As only the interviews were coded, not the prompt texts themselves, the code does not include every polysemous word in the prompt texts.)

In total then, we compiled a list of 20 polysemous words that had been discussed at some point in the interviews, either produced by the children or through the researcher asking about them in discussion of the prompt texts, as follows:

assemblies, attract, capital, concentration, conductor, current, energy, impact, including, mean, measure, model, Moorish, net, product, resistance, significant, static, transfer, volume

Metaphor was not the only issue here, as we show in the next section. The interview discussions suggest that all types of polysemy can create problems for children, but we needed to isolate metaphorical polysemy. The next step therefore was metaphor identification and the exclusion of all non-metaphorical polysemy.

3.3 Procedure: Metaphor identification

We used the MIP (Pragglejaz, 2007) to decide which of polysemous words we had identified had a metaphorical relationship with another sense, one which the children were more familiar with. MIPVU (Steen et al., 2019) is a procedure developed from MIP, and having much in common with it. Although more recent, we preferred MIP for our purposes because of the treatment of part of speech. MIP allows for metaphoricity to be recognised across different parts of speech and lexicogrammatical patterns while MIPVU, in general, does not. In our view, the MIP approach aligns with children’s understandings of word meaning: our interviews indicated that children (1) are not confident in distinguishing different parts of speech (e.g., they confused the adjective and noun meanings of *current* in our data) and (2) are encouraged by their teachers to use clues in word roots and formation to work out unknown meanings (e.g. Quigley, 2019).

We now explain how we followed and adapted MIP for this study.

Step 1 of MIP requires the analyst to read the entire text, which in this study referred to the group interviews and the sections of prompt texts that the children referred to.

Step 2 is to identify lexical units. As we were not aiming to code the entire interviews for metaphor, we did not do this, instead analysing only lexical units that were mentioned in the interview discussions, as described above. That is, we identified mentions, not uses.

Step 3a is to identify the meaning in context. In our study, we interpreted this to be the meaning intended by the teacher or materials writer who produced the lexical item. We were able to refer to a corpus of materials and teacher talk from the children's schools, and to consult with the teacher-advisor to assist with this step.

Step 3b is to establish if there is a more basic meaning (more concrete, precise, related to the body, older). We consulted the Longman Dictionary of Contemporary English (LDOCE)¹ for information about contemporary use and the Oxford English Dictionary (OED) for historical information. We also used the British National Corpus and BNC2014 (Spoken) for the former.

Step 3c is to establish whether meanings 3a and 3b are related by comparison. If they are, there is a metaphorical relationship. Definitions from LDOCE and the OED supported our introspective analysis for this step.

4. Findings

4.1 Metaphors identified in the polysemy theme

Of the 20 instances of polysemy that we identified, we used MIP to decide that 8 pairs of meanings were not metaphorically related, but rather homonyms, homophones or related specific instances of a general meaning. Two pairs of homonyms were identified: firstly *capital* (noun), as used in "The capital of France", and *capital* (adjective), now archaic, used to mean excellent, in works by Dickens; and secondly *mean* (adjective) meaning unpleasant or cruel, and *mean* (noun) meaning "average", in mathematics. The children spontaneously produced these as examples of a new, puzzling meaning of a known word. For both words, consulting LDOCE and the OED led us to conclude that there is no discernible relationship of comparison between the pairs of meanings. One pair of homophones was alluded to: the children encountered the word *Moorish* in a text about Granada.

1. MIP used the Macmillan dictionary for this purpose, but this is no longer available online. We therefore chose LDOCE instead; LDOCE is a corpus-based dictionary aimed at the same readership as Macmillan.

They had not seen the word before and one group joked that it might mean *moreish* (an informal word describing something, usually food, that you tend to want to consume more of than you should).

After Steps 3b and 3c, we decided that a further five pairs were specific uses of a broader general meaning (Cruse, 1986), or use of the same meaning with collocates that the children were not familiar with, rather than cross-domain metaphorical transfers. These were:

assembly, attract, measure, significance, transfer

For example, two groups mentioned *assembly*. The use they were familiar with refers to a meeting of everyone in their school or year group, in the school hall at the beginning of the day. Some struggled to understand its wider meaning, referring to any kind of purposeful large meeting, as used in one of the prompt texts.

Having decided to exclude these 8 words, we were left with 12 which had been discussed during the interviews. These were:

concentration, conductor, current, energy, impact, including, model, net, product, resistance, static, volume

The following tables show the meanings used in educational materials, and the meanings mentioned by the children in the interviews. Not all of the meanings they describe are correct in adult terms. We have used MIP to attempt to decide which of the meanings in the school materials and mentioned by children is metaphorical and which basic, but we acknowledge that this is not straightforward. We also note that an argument for metonymy could be made in some cases. This is particularly relevant because Rundblad and Annaz (2010) found that school-aged children performed better on comprehension tests of metonymy than metaphor, and argue that metonymy is cognitively more basic. When naturally-occurring examples are explored, a complex picture emerges, with metaphor and metonymy often interacting in a variety of ways (Denroche, 2018). Analysing each of these in our data is beyond the scope of this study, and we have therefore used “metaphor” to also encompass mappings that could be analysed as grounded in metonymy.

Table 4 shows words whose school meaning is metaphorical, in contrast to the meaning which the children gave, which we judged most likely to be the basic meaning. Table 5 shows words whose school meaning we judged to be basic, in contrast to a metaphorical meaning given by the children. In some cases, etymology contrasts with other indicators of basicness, and where this happens, we prioritise current usage as the indicator of basic meaning.

Table 4. Metaphorical school meaning

Word	Meaning in school	Meaning(s) mentioned by children	Notes
concentration	density of particles in a gas or liquid	<ol style="list-style-type: none"> 1. think hard 2. in 'concentration camps' 	LDOCE gives children's meaning 1 first and this is basic, as referring to human behaviour.
conductor	substance that allows electricity to pass through	<ol style="list-style-type: none"> 1. person who takes money and gives out tickets on a bus or train 2. person who leads an orchestra 	LDOCE gives the children's meanings first. We regard them as basic.
current	flow of electrical charge	<ol style="list-style-type: none"> 1. flow of water in a river 2. strong, dangerous force in the sea 3. at the present time 	Children's meanings 1 & 2 are listed first in LDOCE and are earliest (OED).
energy	in physics, capacity to do work	a personal capacity or feeling of liveliness	LDOCE lists the children's meaning before the specialist physics meaning.
impact	the result on a society of a historical event	<ol style="list-style-type: none"> 1. physically hitting a surface hard 2. personal emotional response to an event or news 	Children's meaning 1 is basic. Their meaning 2 is metaphorical, contrasts with school 'societal' meaning, in being personal.
model	a simplified conception, introductory theory	<ol style="list-style-type: none"> 1. a toy, a miniature version of something, a picture 2. something that is fake 	Children's meaning 1 is basic and earlier (OED). Their meaning 2 is not documented in dictionaries.
product	the result of multiplying two numbers	goods from a shop	LDOCE gives children's meaning first and it is basic. School meaning is earlier (OED)
static	(adjective) electrical charge held in an object rather than flowing	<ol style="list-style-type: none"> 1. still, not moving 2. electricity 	Children's meaning 1 seems basic as refers to the human body, but it is not identical to the adult use.

Table 5. Basic school meaning

Word	Meaning in school	Meaning(s) mentioned by children	Notes
including	(preposition) indicting that what follows is part of a larger group	(verb) bringing another person into the group so that they are not left out	Children's meaning is a later metaphor from basic meaning of verbal <i>include</i> meaning 'physically contain'.
resistance	1. people's opposition to intimidation, invasion or conquest 2. slowing the conduction of electricity	not giving in to temptation	school meaning 1 is seems most basic and is earlier (OED).
volume	bulk, dimensions	loudness	School meaning is earlier (OED) and more concrete. LDOCE gives children's meaning first (possibly psychologically basic for a child).

Finally, there is only one instance where children mentioned the same meaning as intended by the materials writer or teacher and only that one, *net*. The school meaning is “a representation of a three dimensional shape flattened out”, and the children gave the same meaning. This example was produced in an interview in the second round, in response to the researcher asking what new words they had learned recently that they found hard. The children made no mention of the basic meaning of *net*, (“object used for catching fish, animals etc made of loosely woven material”). They were not asked about it, so it is not possible to know whether they had made a connection between that meaning and the technical maths one. Given that *net* is in the 3rd 1000 band in Nation's headword lists, which are based on frequency and range of coverage in the BNC and COCA (2016), we assumed that the children would know the basic meaning.

Volume was mentioned in response to the same question, by children at two different schools. Both groups of children were aware that they were learning a new meaning (“bulk”) of a word they already knew. *Product* and *static* were produced in answer to the researcher asking what kinds of vocabulary they had been tested on. The child who produced *static* offered both meanings together: “*Static* sometimes means still or electricity”, while the following exchange took place around *product*:

Interview extract 2 Ash school

-
- Nina pretty much everyone got confused with the *product*
- Researcher yes
- Nina I was like the milk or like that's the like stuff you get in like yeah *product* from the shop or something
- Researcher yes yes (laughing)
- Nina everyone got confused with it
-

The 4 words discussed above, *net*, *product*, *static* and *volume*, were produced by the children themselves as examples of words having new meanings, and as seen in the interviews, their understanding of these meanings was generally secure. The remaining 8 words with metaphor-based meanings occurred in the prompt texts. After being given time to read the texts, the children were either asked about a specific word, or whether there were any difficult words. For these 8 words, despite having seen them in context, virtually none of the correct meanings were given. There is a tendency for the meanings that the children gave to be related to their immediate, personal experience, generally overriding the contextual information they had just seen. For instance, in the third round of interviews, children read a text about the Black Death (a topic they were studying in history). It began:

Prompt text extract 1

Below are examples of how the villagers responded to the oncoming Black Death: Very large transfers of land took place, *including* gifts of land to Robert and William Cranmer from their father.

The researcher asked them about *including*. One response was:

Interview extract 3 Sycamore school

-
- Eva like when you *include* things so like if you left someone out
- Researcher oh okay
- Eva like in a game you have to *include* them
-

Eva's definition might be considered a metaphorical extension of a related verbal use, and it is also newer (OED). This meaning is clearly something that is close to her experience as a school child; teachers often tell children to be sure to *include* others in their activities and ensure nobody is left out. It is probably for this reason the meaning that she thinks of first when asked, rather than the meaning that corpus and dictionary evidence, and adult intuition suggest is the basic meaning.

(The adjective *inclusive* has a related meaning, but we thought it very unlikely that this was a source of confusion, as our 3.5 million word corpus of school language, developed in the same project, contains only one instance of the word, with a different meaning, in mathematics. This suggested that it would be unlikely to be a use that occurred first for children.)

Other cases where children seem to default to a meaning that is very close to their personal experience as school children are *concentration* (they are told repeatedly to concentrate in class) and *model* (loosely described as a toy, or a small version of something, such as a model car). Individual, personal experience is the meaning they think of first in describing *energy*, *impact* (a personal reaction to events), and *resistance*. These contrast with the related academic meanings, that is, the abstract scientific meaning of *energy*, and the meanings in their history curriculum of *impact* and *resistance*, which refer to the behaviour of large societal groups of people rather than individuals.

We now look more closely at *current*, as this is a word that was discussed in detail by all the interview groups, and is also often discussed in the metaphor literature (e.g. Smedinga et al, 2023). It was discussed in the third round of interviews, once children were at their secondary schools, and was used in a prompt text, which began:

Prompt text extract 2

How much current will flow around a circuit?
All materials are made of tiny particles called **atoms**, and all atoms have even smaller particles called **electrons** inside them. In some materials the electrons can move around easily. An **electric current** is a flow of electrons and carries **electrical energy**.
(bold text in original)

While the text contained several words from the source domain of water, the researcher chose to ask the groups specifically about *current*. All 5 interview groups discussed the meaning, with just one child of the 30 giving an explanation that approximated to the use in the text, although slightly unclear, as follows:

Interview extract 4 Elm school (1)

Aris a *current* is like it's something that flows round like and doesn't really get it doesn't stop it like flows round and it's like it something's in it like a river can have a *current* it's where it goes and like in an electrical circuit like it says here its *current* is like electrical it's like something like it could be powering something or.

Two groups refer to a basic meaning, of direction of flow in a river, but it is unclear whether they are all aware that the use is different here.

Interview extract 5 Sycamore school (1)

-
- Researcher What about *current* though?
- David *Current?*
- Researcher How much *current* will flow around the circuit?
- Nathan electric
- David oh I thought it meant water like do you know when there's a river? Like it has a *current*.
- Researcher Yeah
- David That's what I thought it meant
- Nathan That's the same thing it's just like with electricity
- David electricity in a river what now? (laughs)
-

Interview extract 6 Elm school (2)

-
- Researcher okay thank you what is *current*?
- Elsie I know what it is in a river but I don't [children laughing]
- Researcher There's a picture and a definition there could you infer the meaning?
- George [.....]
- Elsie (reads aloud) a flow of electrons
- Researcher mhm
- Elsie but I don't know what electrons are so that doesn't help.
-

Another group talk about the sea rather than a river, appearing at first to confuse *current* with *tide*.

Interview extract 7 Sycamore school (2)

-
- Niall the *current* in the sea like the *current* ... goes out
- Lily it's like a thing goes through something or something like that
- Niall it's pushing you back out
- Researcher could you please repeat that?
- Niall *current* like in the sea. Sometimes the *current* is really rough.
- Kyle yeah
- Eleanor and it pulls you out to sea
- Niall pulls you out to sea
- Researcher is it the same thing here though?
- Seamus No
- Niall could be cos it's pushing it out
- Eleanor yeah like pushing the electrons
- Seamus isn't it the way that like the electricity moves through the wires here
-

The discussion seems to work towards implicitly mapping currents in the sea onto the target domain of electricity, leading to the point where Seamus articulates the academic, metaphorical meaning quite well. However the attributes that seem to have been mapped from the sea as source domain are “force/ pushing”, and possibly “danger”, rather than directionality through a narrow channel, which underlies the conventional understanding of the metaphor.

Finally, one child offered a completely different meaning for *current*, despite having read the text on electricity a few moments earlier.

Interview extract 8 Holly school

Researcher mm what is *current*?

Theo like when you are doing something now?

The researcher asks him about this and draws his attention to a diagram of an electrical circuit in the text:

Researcher but is it the same thing here? or is it something different?

Theo I don't.

Researcher There's a picture

Theo Oh there's. so it's going on and on. I don't know.

Theo seems to be trying to reconcile the “time” meaning of *current* with the contextual meaning, by thinking about the continuous, ongoing nature of an electrical circuit. He in fact comes close to describing the metaphorical meaning, but gives up.

Similar patterns were found for the other words when the researcher asked them if they understood the words in the text, making it clear in each case that she was referring to their contextual meanings. For example, moments after reading a science text explaining the concentration of particles, almost every child explained *concentration* as “when you think hard”, with a few also recalling what they had learned recently about concentration camps. Shortly after reading a science text referring to electrical *energy*, the children defined *energy* in terms of a personal resource, for example “like when you're running about and can be bothered to do stuff not just lay on the sofa like”, and “when you play football you run around a lot like you need a breather and then when you breath like your energy comes back to you”.

4.2 A metaphor identified in the definition/ explanations theme

In the second round of interviews, all 5 interview groups discussed a prompt text recommended by the teacher-consultant which attempted to explain the notions of diffusion and concentration in science. This is the final paragraph of the text.

Prompt text extract 3

How do substances move in and out of cells?

Substances move in and out of cells by diffusion. Diffusion is the movement of particles from a place where they are in a high concentration to a place where they are in a low concentration. The concentration of a substance means the number of particles of a substance present in an area. Think about what happens when someone burns toast. The particles that make up the smell of burnt toast move from a place of high concentration (the kitchen) to one of low concentration (the rest of the house). At first, you may only be able to smell the burnt toast in the kitchen. A short time later, you may be able to smell the burnt toast in the living room.

The use of the analogy to burning toast to explain particle diffusion has several characteristics of a pedagogically sound approach, as suggested by Cameron (2002). We noted that the target domain: cells, substances and diffusion; is outlined. The metaphor is signalled with "Think about what happens when...". The mapping of the source domain, the house, to the target domain, cells and their surroundings, is made reasonably explicit. The text was written for children aged 11–12 in England, for whom making toast and occasionally burning it would be a very familiar source domain, and not a complex one. In the group interviews, the researcher did not ask directly about this metaphor, but she did ask the children if there were any sections of the text that they found challenging. In 3 of the 5 interviews, a child mentioned the metaphor, as follows.

Interview extract 9, Ash school

-
- | | |
|------------|--|
| Nina | I think I found like the examples like "think about what happens when someone burns toast [...]" and at first like that kind of like example I found it very confusing |
| Researcher | why is it confusing? |
| Nina | 'cos it 'cos I understood like when you say like at the kitchen you smell burnt toast but then but then I didn't but then I don't know how to explain it |
| Researcher | so you couldn't really understand the example? |
| Nina | I don't really understand the example like |
-

Interview extract 10 Birch school

Sophia ... I've read about it before only not in that much detail so it's quite new, and it confused me why it made a reference to burnt toast of all things

Researcher mm why?

Sophia because it was talking about cells and like burnt toast it's such a random thing to go to I think

Interview extract 11 Beech school

Alfie well I don't really think oh sorry I think I only found like the thing about when someone burns toast bit I just thought that's a bit weird why would you put burnt toast in a thing about cells?

These three different groups of children did not know each other and attended schools at some distance from each other, yet had a fairly consistent experience in struggling to see the relevance of this analogy. None of the other children present in the three interviews were able to offer an explanation for the metaphor. The difficulties experienced by such a large proportion of our sample suggest that the use of analogy and metaphor in teaching for this age needs to be investigated further, so that educators can be advised how best to structure and use them.

5. Discussion

We now return to our research question:

What difficulties, if any, do 10–12 year old children in England have with the vocabulary of school when it involves:

1. polysemy generally, or
2. metaphor-based polysemy specifically?

Our data suggest that children of this age have some awareness that words can have multiple meanings. When asked what new language they were learning, a small number of their examples were new senses of known words. However, when faced with new polysemous words in the prompt texts, they sometimes seemed unaware that a new meaning is intended at all. They showed a strong tendency to fall back on known meanings, even where these do not plausibly fit the discourse context.

The new meanings that caused difficulties were not always metaphorical extensions of a known literal meaning. In some cases, children already knew a metaphorical meaning of a word, and the cause of difficulty was its literal meaning. We do not have enough data to estimate which scenario is more frequent.

Further, in many cases it was difficult to decide objectively which meaning is more basic. Nonetheless, there is sufficient evidence to claim that metaphor is at play in many cases of confusion.

The findings from our interview data are consistent with previous findings (e.g. Nippold, 2006; Rundblad & Annaz, 2010), that even typically developing children have difficulty with interpreting metaphor and analogy. The ability to inference across different meanings is not fully developed, even less so where metaphor is concerned, at the beginning of secondary education. Learning new meanings of words is central to progress in school, and conventionalized subject-specific metaphors need to be taught, with explicit attention. The “burnt toast” discussions suggested that even with support and explanation, the point of an analogy can be missed.

6. Conclusion

A limitation of the current study is that the interviews by their nature produced a bias towards word meanings that children found difficult, and far less information about words they handled well. Further, the majority of the words that came up were from the texts that our teacher-advisor had chosen; while these are age and topic appropriate, they offered a very limited number of examples for probing in the interviews. For both these reasons the words themselves cannot be regarded as a fully representative sample of polysemous words and/or metaphors used in early secondary school.

A strength of this study is that it took place in an environment that is natural and familiar to the participants. In England, where the study took place, approximately 93% of children attend state schools, which follow a central government-mandated curriculum. They spend 39 weeks per year in school. For many children, school texts constitute a very large part of their written language input, and to be successful in the academic system, they need to understand them. Our wider corpus-based study (Deignan et al., 2023) found that metaphorical language is used in all subjects, meaning that difficulty with understanding it may cause problems across the curriculum. The children's responses suggest that they are not yet fully able to use the power of metaphor as a learning tool. The implication is that they may be missing or misunderstanding a proportion of the subject material presented to them. Further research involving larger numbers of words and carefully controlled elicitation would be valuable to give more detail to the picture suggested here.

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