



A Subject Language Model of *Interpreting Representations in their Intended Senses*, IRIS

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RESEARCH



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ABSTRACT

Understanding subject-specific texts requires interpreting representations—words, symbols, and images—in their intended senses. Many such representations are ambiguous, with meanings that shift depending on context and disciplinary conventions. This applies not only to words, for example, ‘paper’ in everyday versus academic usage, but also to symbols and images, like ‘–’, that must be interpreted in different senses depending on context. This article introduces *the IRIS model (Interpreting Representations in their Intended Senses)*, a theoretical framework designed to capture the interpretative processes readers engage in when navigating subject language. Unlike existing models that focus primarily on vocabulary, IRIS encompasses all semiotic resources and foregrounds the discernments needed to resolve ambiguity. Analytically, it supports text studies by making explicit the interpretative demands posed by subject-specific representations. Pedagogically, it offers a tool for fostering metacognitive and metalinguistic awareness, helping learners and educators reflect on the challenges involved in interpreting subject languages.

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INTRODUCTION

This article presents a subject language model of *Interpreting Representations in their Intended Senses* (hereafter referred to as *IRIS* or the *IRIS model*). The purpose of IRIS is to capture what is demanded from everyone who communicates in and about a particular subject, to correctly interpret representations; that is, determining the intended or most probable sense in relation to the context. In the theoretical description and visualisation of this interpretation process, IRIS foregrounds ambiguous representations, those whose meaning is not immediately transparent and must be inferred through contextual cues and disciplinary knowledge. While some representations are straightforward to interpret, IRIS is designed to address those that pose challenges to comprehension. Unlike many language models, IRIS operates on all types of representations, giving equal importance to verbal, symbolic and visual language.

The IRIS model was originally developed to address the challenge of distinguishing mathematical notation from surrounding text in a corpus of digitised textbooks (as described by Ribeck Nyström and Dyrvold, 2019). Its development has been informed by research on applied linguistics. For example, the distinction between *everyday*, *academic*, and *technical* vocabulary that is used in the model, is well-established in language acquisition and educational linguistics. These *registers* are often incorporated into language models that address literacy development (e.g., Nation 2001; Shanahan and Shanahan 2008). A common mechanism in establishing both academic and technical vocabulary is to repurpose an everyday word, imbuing it with specific connotations and meanings, resulting in that the same words can carry different meanings depending on the linguistic and subject-specific context. Interpreting such words in their intended sense thus becomes a context-dependent process, requiring in-depth knowledge of how language and other representational forms are used within a given subject. While some of this knowledge pertains to broader disciplinary frameworks, IRIS has been developed with an educational focus and is intended for use with texts related to school curricula.¹

THE GAP FILLED BY IRIS

IRIS provides a structured approach to interpreting representations in subject language. To understand the need for such a model, it is essential to consider the nature of these representations and the interpretive demands they place on learners. These demands often involve ambiguous or multisemiotic forms that existing models struggle to account for adequately.

SUBJECT-SPECIFIC REPRESENTATIONS

The concept *representation*, which stands for a verbal, symbolic, or figurative description or portrayal of something, is used in both research and teaching. Representations can be very comprehensive, as an exploded view diagram representing how different parts fit in an engine, but a single digit as '3' is also a representation (of the concept three). In printed texts, three kinds of semiotic resources are used in representations, namely *verbal language* (e.g., words, letters), *symbolic language* (e.g., punctuation marks, mathematical notation), and *visual language* (e.g., pictorial or schematic images). While these semiotic resources can be distinguished analytically, they are often intertwined in practice; many units, for example, combine verbal and symbolic language (e.g., 'm/h'). Such a mixture of resources increases the complexity of interpreting text.

Another layer of complexity arises from the fact that many verbal representations take a *subject-specific* meaning when they are used within the context of a particular subject and may carry meanings that differ from their everyday usage. Subject-specific use of representations includes what is commonly referred to as *technical* language. When a word or expression is used in a technical sense, it typically refers to a formally defined concept that requires specialist knowledge to be fully understood. Technical terms are precise, standardised, and often explicitly defined within the discipline. These technical representations often reflect the conceptual frameworks and communicative practices of a specific field. To further complicate matters, highly symbolically dependent subjects, like mathematics, have developed an intricate symbolism (Cajori 1929; Pimm 1987). The use of letters as mathematical notation is an example of representations whose correct interpretation is context dependent. For example, the token 'e' is interpreted as the *letter* when enclosed by verbal language, and as the *irrational number* ($\approx 2,7$) when enclosed by mathematical notation. The same ambiguity applies to symbolic language (e.g., '!' [exclamation mark or sign for factorials]) and images (e.g., an arrow [pointing symbol or vector]). Readers must therefore often engage in context-dependent interpretations of representations.

Given the complexity and context-dependence of representations used in subject languages, there is a clear need for a framework that can support interpretation across these varied forms, and that provides a conceptualisation of the process. The diversity in how representations are constructed and employed enhances their effectiveness in conveying particular aspects of a subject. However, this variability also places demand on the reader, who must be able to discern the intended meaning of each representation within the context of a given text. To succeed in the classroom, learners must learn to navigate between everyday language and the

language specific to the subject at hand, where the meaning of representations often shifts between the two (cf. Cirillo, Richardson Bruna, and Herbel-Eisenmann 2010; Jourdain and Sharma 2016; Roberts and Truxaw 2013). Research shows that students frequently struggle to distinguish between the everyday and technical meanings of words (Parszyk, 1999). This challenge is particularly evident in mathematics, where symbolic representations embedded in the subject's technical language often conflict with students' everyday ways of expressing and interpreting meaning. As Simpson and Cole (2015, p. 378) put it: "symbolic representations, inherent within the technical language of mathematics, are at odds with students' everyday language and sign system." These challenges related to the interpretation of subject-specific representations are addressed in the IRIS model.

MAKING SENSE OF SUBJECT LANGUAGE

The IRIS model is a framework for understanding and scaffolding the complex processes involved in making sense of subject language. It is relevant to all subject languages with their representations. In this article, however, the subject language of mathematics is used as a reference due to its reliance on various semiotic resources and diverse representations used to communicate with precision (Lemke, 1998). Consider the mathematics task in Figure 1, a typical example of how

particular representations are used for different purposes in contemporary textbooks in mathematics.

For the experienced reader, a task like this is easily interpreted. However, a closer reading of the text reveals intricate interpretative processes needed to understand the task. Representations that seem unequivocal in fact demand interpretations that depend on the subject at hand and the particular wording of the task. For example, the word 'expression', which in everyday senses may refer to either an act of saying or showing what you think or to the look on someone's face, here needs to be interpreted in a subject-specific manner in order to correctly understand subtask a). The symbol '-' between the years 2010 and 2020, on the other hand, shall not be interpreted in a subject specific manner (as a minus sign), but rather as an academic interpunctuation mark, an en dash, indicating a range of years. Discernments like these continually need to be made when reading subject-specific text.

Another interpretative challenge for readers of subject texts has to do with the ability to correctly identify representational boundaries. This challenge is perhaps most evident in relation to images. Consider for example the representation of a triangle in Figure 2. This representation also encloses other representations, such as the labels A, B, C and D, or h and the dashed line, which represent the 'height of the triangle'. Such additional representations may or may not enable more

In 2010 Anne made a 5000 \$ deposit at Citibank which offered a 10 % yearly revenue.

- Write an expression for the value of the money, x years after the deposit was made.
- Which of the graphs below, f, g, or h, depicts the growth of Anne's money 2010–2020?

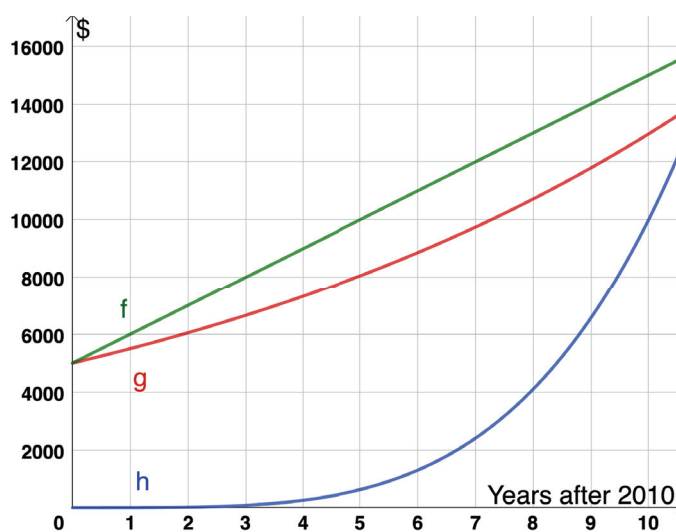


Figure 1 Mathematics task.

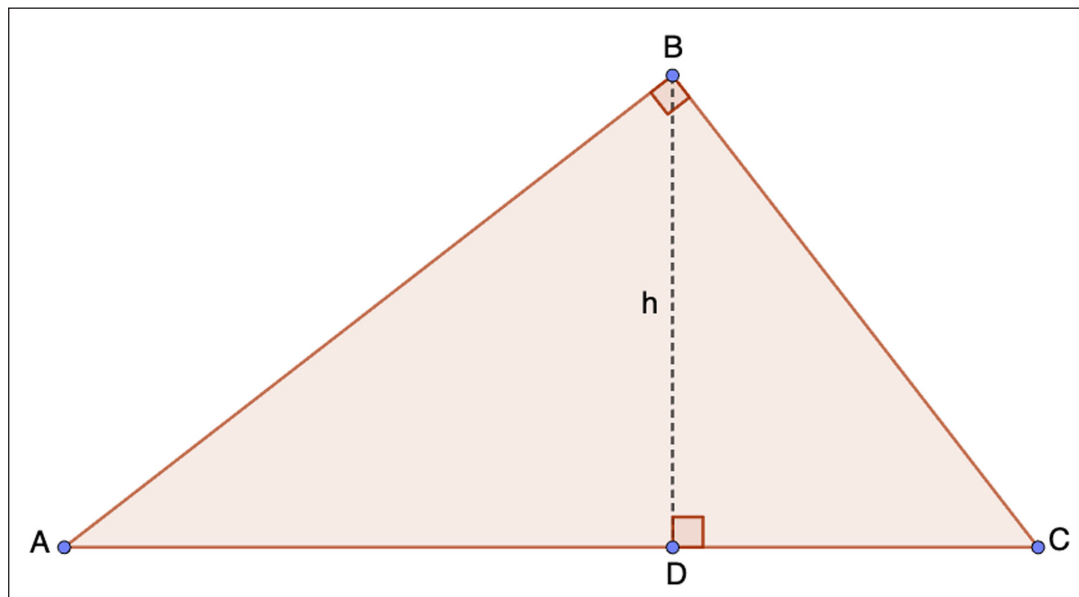


Figure 2 A representation of a triangle enclosing other representations.

specific interpretations of the *main representation*. An example of a specifying additional representation is the square at B, which marks a right angle. On the other hand, many additional representations serve no, or at least less apparent, specific semantic functions, but are rather included for aesthetic purposes. In [Figure 2](#), this holds true for the small markers at points of intersection or the shading of the main representation.

Being proficient in reading representations in subject languages requires the ability to identify the main representation and to analyse how its additional representations relate to it and to each other. Noteworthy, the boundaries for what are meaningful interpretative units are not always as clear as this example, and more importantly, not always clear to learners.

EXISTING SUBJECT LANGUAGE MODELS

The perception that there exists a kind of informal language use that differs from that used within the frame of teaching originates from second language acquisition (cf. [Cummins 1981](#); [Hulstijn 2011](#)) and now recurs in many research fields. Cummins ([1981](#)) uses the acronym *BICS* (Basic Interpersonal Communication Skills) to refer to the language use that occurs in familiar home environments, in direct communication between people “here and now”, and *CALP* (Cognitive Academic Language Proficiency), which is related to reading and writing skills particularly used in teaching situations. Similarly, Hulstijn ([2011](#)) distinguishes between *BLC* (Basic Language Cognition), which is the common language knowledge that native speakers have, and *HLC* (Higher Language Cognition), which also includes literacy skills.

The most well-known and cited division of vocabulary from a learning perspective derives from Nation ([2001](#)), who, based on empirical evidence, categorises vocabulary into four types: *high-frequency words*,

academic words, *technical words*, and *low-frequency words*. High-frequency words, including both *content words* (e.g., ‘forest’, ‘boundary’ etc.) and *function words* (e.g., ‘for’, ‘the’, ‘of’, ‘a’ etc.), are prevalent in all text types, while academic words (e.g., ‘concept’, ‘structure’, ‘evident’ etc.) are common across different academic texts. Technical words frequently appear in specialised subject texts but are virtually absent outside their field of study. Technical words often require specialist knowledge and are considered *terms*, due to their precise meaning. Last, low-frequency words are generally unusual words that may have specific connotations such as being old-fashioned or dialect-specific. Nation’s vocabulary model merely presents the various categories that exist, without providing any guidance on how a reader of a text determines the category to which a particular word belongs, aside from the possibility of looking up the word in various types of dictionaries. In relation to his division, without further problematization, Nation ([2001](#), p. 19) points out: “Where technical vocabulary is also high-frequency vocabulary, learners should be helped to see the connections and differences between the high-frequency meanings and the technical uses. For example, what is similar between a cell wall and other less specialised uses of wall?” Thus, Nation acknowledges the potential complexity associated with different meanings of words and suggests that these words are addressed in teaching.

Another influential vocabulary model, contemporary with Nation’s, is the more subject language oriented, *Three Tier Model* ([Beck et al. 2002](#)). This model categorises vocabulary into three groups or tiers: *basic or common words*; *words used across the curriculum and words with multiple meanings*; and *content-specific vocabulary*. With regard to the tier of multiple meaning words, Sibold ([2011](#), p. 25) clarifies that: “[w]ords such as *set*, *bat*, *base*,

and check have several meanings and must be presented in context in order to be understood”. Although the Three Tier Model theoretically recognises that many words require context for interpretation, its visualisation provides no insight into how this interpretation is conducted.

Altogether, existing subject language models (see also [Monroe and Panchyshyn 1995](#); [Schlepppegrell 2007](#); [Simpson and Cole 2015](#)) show room for improvement in two key areas: the perception of language registers as fixed domains, and the predominant emphasis on verbal language. In the following, these two aspects are elaborated in turn.

Existing models often put forward a simplified view of words as belonging to either a subject-specific, an academic or everyday domain. Everyday words that take specific meanings in academic or technical domains, are described as exceptions, if mentioned at all. Discernments needed in relation to disambiguating ambiguous representations are without a doubt central to grasp the intended meaning (cf. [Beck et al. 2002](#); [Sibold 2011](#); [Moschkovich 2015](#)). Yet, no model uncovered offers any guidance in how this interpretation process is carried out by a reader of subject text.

The second aspect is that the language models mainly are concerned with describing registers that make up the *collected* inventory of the language. Most models, however, exclusively describe vocabulary, or originate from verbal language and treat other semiotic resources more or less as exceptions. This narrow focus fails to account for a fundamental characteristic of many subject languages, their inclusion of non-verbal resources. Despite being central to meaning-making in disciplines like mathematics, science, and geography, other semiotic resources than verbal are often neglected or marginalised in theoretical frameworks. As a result, current models offer an incomplete and skewed understanding of how knowledge is actually constructed and communicated in subject-specific contexts. To address this gap, we propose a model that foregrounds the interpretive work involved in making sense of subject-specific texts, that often relies on more than just verbal language.

INTRODUCING IRIS

The subject language model IRIS conceptualises the discernments that a reader needs to make when interpreting a subject-specific text. In contrast to many other language models, IRIS depicts an interpretive process, thus having a direction. It is applicable to any representation, main or additional, aiming to determine the intended or most probable sense in relation to the context.

IRIS emphasises the following:

- All semiotic resources deserve equal consideration and weight.
- Ambiguity is a central challenge in subject language, where words, symbols, and images often carry multiple potential meanings.
- In subject-specific contexts, the ability to resolve ambiguity is essential for understanding.

This section first outlines the interpretative process captured by IRIS. It then clarifies how the model accounts for different types of representations and discusses its relevance for both experienced readers and learners. Last, design choices and theoretical foundations from semantics and pragmatics are briefly presented to situate the model within broader linguistic research.

THE MODEL

Put short, IRIS documents the following interpretation process: For each representation, the reader first determines whether it pertains to a specific subject or not. If it is subject-specific, the next step is to discern whether the representation is relevant to the current subject or another subject. For non-subject-specific representations, the focus shifts to whether the representation is used in an academic or an everyday manner. In the considerations needed when interpreting representations ([Figure 4](#)), there is a recurring two-step path of discernments ([Figure 3](#)).

[Figure 3](#) describes that first an attempt to discern the sense of a representation is made based on knowledge. If knowledge is not sufficient to identify the sense, the representation is ambiguous and a second trial of discernment is made, now also based on context. This path recurs in three parts of the visualised IRIS model ([Figure 4](#)), which depicts the overall path from seeing a representation (top) to attributing it to a particular sense (bottom). Experienced readers are familiar with the representations used in their field of study, and for them, this process is automatised. However, for representations that are new to the reader or appear in a new context, the path can also encompass conscious considerations, even for experienced readers. For a learner, on the other hand, the need for these specific considerations can be a source of misunderstandings.

In the IRIS model, *technical sense* means a representation shall be interpreted with a meaning that is specific to a particular subject language. The specific meaning can stem either from the representation being unique, that is only used with that technical meaning (e.g., the sign for division ‘÷’ that is used only in a mathematical sense), or from the representation bearing a particular meaning in the subject (e.g., ‘’ denoting the derivative, not an apostrophe). Furthermore, subject-specific representations may exhibit a technical sense either according to the subject at hand (e.g., mathematics),

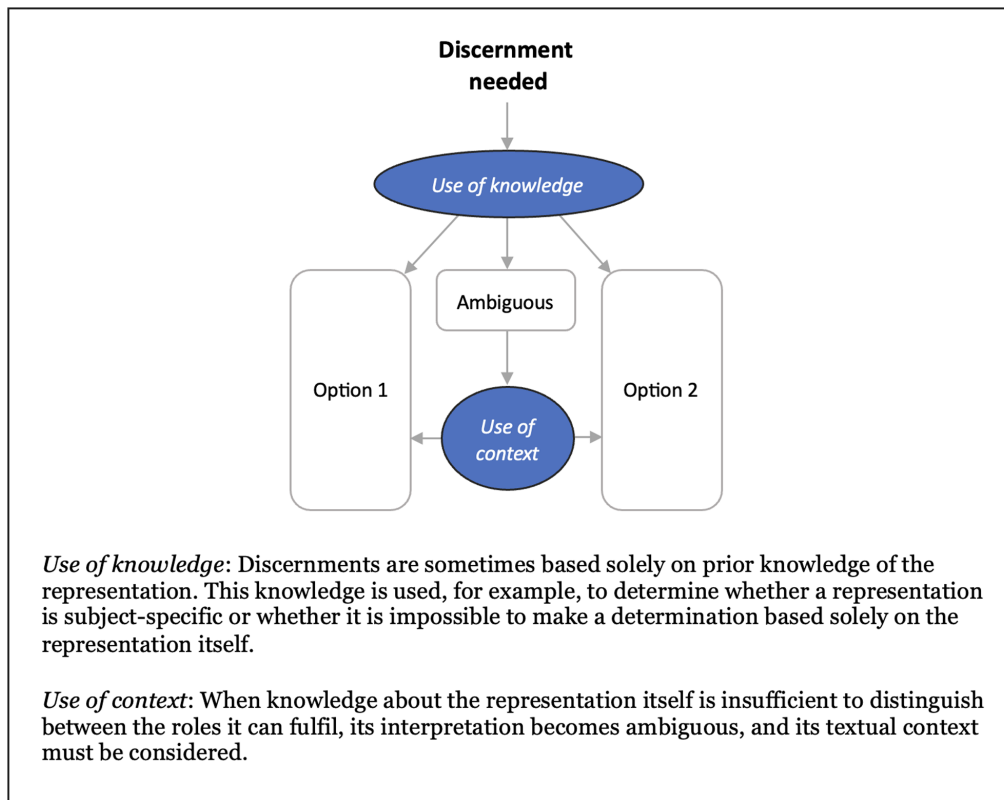


Figure 3 The two-step path of discernments, based on knowledge and context, in the interpretation of representations.

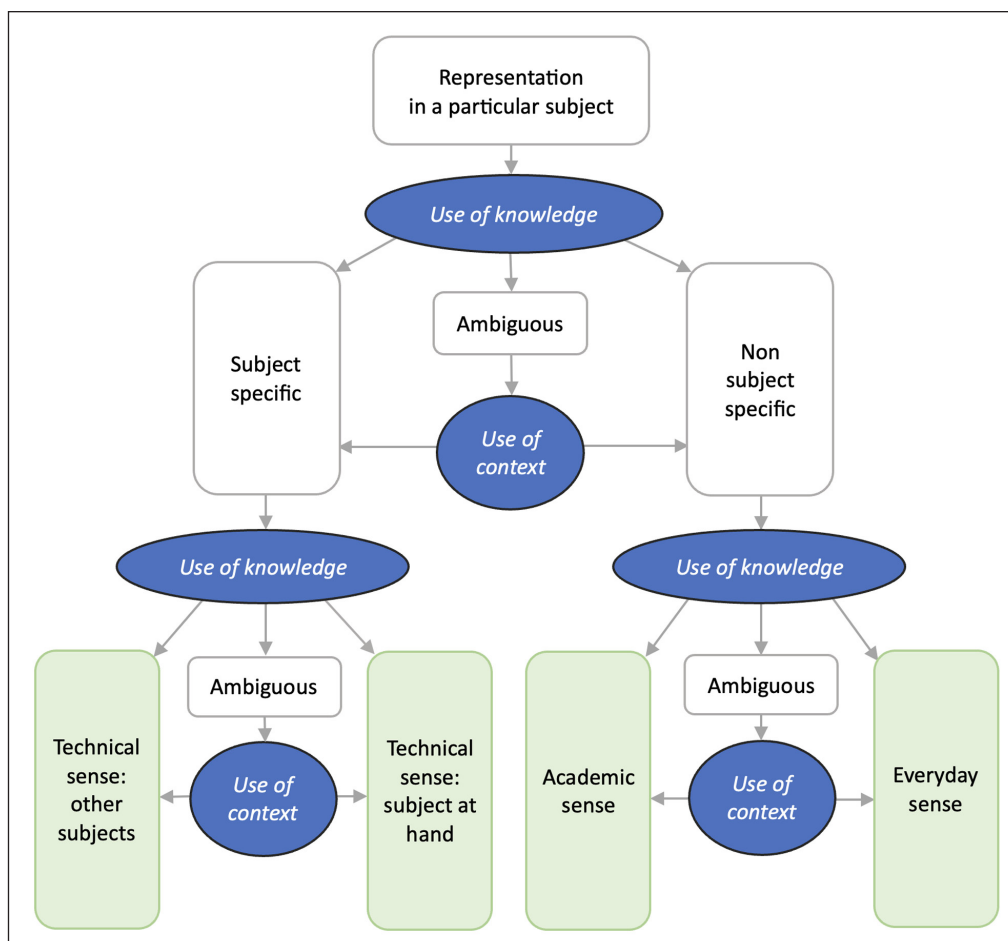


Figure 4 The model of Interpreting Representations in their Intended Senses, IRIS.

or according to other subjects (e.g., if a representation specific to biology is used to exemplify exponential growth in mathematics). *Academic sense* is a more general category, comprising scholarly representations that shall not be interpreted in an *everyday sense*, but at the same time are not specific to the subject at hand. An example is ‘criteria’, an academic word used in many subjects. Many academic representations also have an everyday meaning, and, in such cases, the reader must deduce the intended interpretation. For example, in an everyday sense ‘argue’ means to have a dispute, but in an academic sense it means to give valid reasons for or against something. Accordingly, the reader’s knowledge and the textual context, that may be needed while reading subject-specific texts, are important, and the IRIS model makes knowledge about these interpretative discernments explicit.

IRIS is a theoretical model capturing a reasonable interpretative process, based on which discernments that may be required. As IRIS is a theoretical construct, it is not argued that every representation in all cases is evaluated by every reader regarding the path captured in IRIS. What is captured is what may be needed, but it is also likely that experienced readers after the initial *use of knowledge* stage directly ends up in one of the four senses. If a representation is interpreted instantly, the reader *just knows* and the path through IRIS is superfluous. There is also a difference between which types of representations that are more likely to demand conscious considerations. For example, in practice, there is a substantial difference between interpreting content words (e.g., ‘sell’, ‘algebra’, ‘narrow’) and function words (e.g., ‘and’, ‘by’, ‘the’). The intended sense of content words in text is often both essential and specific to the subject matter, whereas function words tend to be interpreted automatically and consistently, regardless of disciplinary context. In such cases, the IRIS model is not needed or meaningful; interpretation is instead anchored in linguistic convention and contextual familiarity. Similarly, the path through IRIS becomes redundant for images and symbols with universal meaning (e.g., ‘∞’, an image of the Earth, or the font in a newspaper), where interpretation tends to be immediate and unproblematic.

DESIGN CHOICES AND THEORETICAL FOUNDATIONS

Our overall understanding of different types of senses of representations primarily stems from general linguistics, especially from semantics and pragmatics. In semantics, there is the study of word meaning and relationships between different meanings of the same word (as in *polysemous* words), but also concepts like *homonymous* words, that is, different words with unrelated meanings that are spelled and/or sound alike. While semantics is concerned with the literal meaning of words and sentences, pragmatics is concerned with the inferred

meaning, considering the context of the conversation. In pragmatics, there is a well-accepted concept called *contextual cueing* or *pragmatic inference*, which refers to the idea that the meaning of a word or phrase can often be inferred from the context in which it is used (e.g., [Blott et al. 2022](#)). This is especially true for polysemous and homonymous words or phrases ([Tabossi 1989](#)).

IRIS captures ambiguity but makes no distinction between polysemy and homonymy. This semantic distinction is most relevant in linguistic settings, when words and their meanings are to be examined or accounted for. Within IRIS, it is sufficient that a single representation may carry different meanings depending on contextual factors. Such representations are simply referred to as *ambiguous*, as opposed to *unambiguous* representations with a single clearly defined meaning. Discerning between ambiguous representations that are polysemous, for example ‘group’ and ‘equal’, and those that are homonymous, for example ‘axis’ and ‘volume’, involves different cognitive skills. This difference is not explicitly addressed in IRIS but is still within the scope of didactical implications of IRIS.

Interpretation process

The IRIS model captures how necessary discernments are made to determine the intended meaning of ambiguous representations. This process can be relatively straightforward when dealing with unambiguous representations such as ‘bijection’ or the sign for parallel lines ‘ $AB \parallel CD$ ’. However, as illustrated in [Figure 3](#), it is often necessary to distinguish between different senses of a representation. These discernments are guided by what is referred to as *knowledge* and *context*.

Knowledge is used in cases where the literal meaning of a representation can be deduced based on the learner’s present knowledge about the representation at hand, and when that knowledge is sufficient to interpret it. This process is somewhat similar to what was previously described as the concern in semantics; to identify the literal meaning of, for example, words. In IRIS the interpretation process is referred to as *use of knowledge* if there is an unequivocal meaning of the representation the reader knows or can deduce based on the representation per se. Examples are technical representations: a word as ‘polyhedron’, a symbol as ‘%’, or a coordinate system, along with more widely used less ambiguous representations: a word as ‘only’ or an emoticon as ‘;-)’. The use of knowledge for interpretation is based on previous encounters with the representation, but this knowledge does not necessarily need to be fully consolidated. Readers often rely on educated guesses as part of the interpretive process. For example, someone familiar with number lines might infer that a coordinate system should be understood in a technical sense, since its axes resemble number lines. The ability to make such inferences and draw on previous knowledge can

be supported by teaching that draws attention to the specific features of subject languages (cf. [Shanahan & Shanahan, 2012](#)).

Context, on the other hand, is used in cases where the representation itself does not offer all information needed to discern the sense of it. Whereas the use of knowledge is sufficient to find the literal meaning of a representation, *use of context* is also needed for representations whose meaning and sense is dependent on the context they appear in. Consider for example a green quadrangle. A reader must discern what the image is used to represent because the same image can represent a geometric shape, a lawn with a somewhat quadratic shape, or a post-it note. This process is related to what was previously said regarding pragmatics, which is concerned with the inferred meaning, considering the context of a conversation. Accordingly, what IRIS describes as an interpretative process using context has similarities with a pragmatic take on a text. In pragmatics contextual cueing are for example the use of the situational context in a text ([Blott et al. 2022](#)), but the use of contextual cues can also be to recollect previous reading of a representation in context and identify visual cues ([Chun and Jiang 1998](#)).

In the visualisation of IRIS, the use of knowledge and context is represented separately because they represent different processes. There is however a direct and essential relationship between the use of knowledge and context in interpretation—a relationship that the IRIS model seeks to address. Thus, leaving the node *use of knowledge* does not imply that knowledge is no longer used, rather entering the node *use of context*, means that context is *also* needed. As outlined in IRIS, the ability to interpret subject-specific representations relies not only on prior knowledge, but also on the surrounding text, or *co-text* ([Kortmann 2020](#)), which provides immediate linguistic cues that guide meaning-making. More specifically, an important aspect included in the theoretical model, though less apparent in its visualisation, is the need for clear and familiar representations that can serve as anchoring points for interpreting adjacent, ambiguous ones.

Interpretative categories

The specific interpretative categories included in IRIS, that is *subject-specific*, *technical*, *academic* and *everyday*, primarily come from the language models presented by Nation ([2001](#)) and Beck et al. ([2002](#)), whose perspectives on language align with those adopted in this framework. However, in merging the two together, as well as considering the specific aim of the IRIS model, some adjustments to their categorizations had to be done. Given the focus on subject languages, it is important to acknowledge the dichotomy between *the language of schooling* (which encompasses academic and technical words) and the language surrounding it. Therefore, the

high-frequency words-category and the *basic or common words*-tier correspond to the *everyday* register in IRIS, a notion concurring with many other linguistic models (cf. [Parszyk 1999](#); [Cummins 2000](#); [Schleppegrell 2007](#); [Simpson and Cole 2015](#)). Furthermore, although perhaps being important in text types like fiction, oral storytelling and historic texts, Nation's *low-frequency words* seldom occur in subject languages (cf. [Ribeck 2015](#)). Indeed, there is no equivalent tier in The Three Tier Model, and in line with Beck et al. ([2002](#)), there is no specific interpretative category corresponding to rare words in IRIS.

In terms of the other categories included in the model, Nation's simple and clear terminology has been followed, referring to them as technical and academic. However, since the input to IRIS is a specific representation in a certain subject text, it becomes necessary to distinguish technical meanings within the *subject at hand* from those within *other subjects*.

The distinction between subject-specific and technical senses, included in the IRIS model, is important because not all language used within a subject area is technical. Subject-specific usage may include informal jargon, metaphorical extensions, or context-dependent meanings that are familiar to practitioners but not formally defined. In contrast, technical terms are designed to eliminate ambiguity and support rigorous communication. For example, in mathematics, the word 'group' has a technical sense: it refers to a set equipped with an operation that satisfies four specific axioms (closure, associativity, identity, and invertibility). This definition is precise and universally accepted within the field of abstract algebra. Another word used in a subject specific manner in mathematics is 'nice', as in *Let's pick a nice basis to simplify the computation*. The meaning of 'nice' in this context is not formally defined, that is, it is not technical, but the word is not used in its everyday sense either. Despite this difference between subject-specific representations that are technical and non-technical, IRIS does not differentiate between the two. Consequently, 'nice' will end up in a technical sense, even though it has no formal definition in mathematics. However, it is reasonable to assume that a practitioner of mathematics could account for its meaning in a mathematical context and undoubtedly, this meaning is essentially different than the everyday meaning.

With the presentation of the IRIS model now complete, its practical applications are considered next.

APPLICATIONS OF IRIS

IRIS is the result of an extensive process of development and refinement, aimed at categorising representations according to the sense they convey within a given text. Unlike models that merely rely on predefined linguistic categories, IRIS focuses on the interpretive grounds upon

which meaning is attributed. This shift from classification to interpretation makes IRIS particularly suited for analytical purposes, including studies of subject-specific text composition and qualitative textual analysis. Analytical models such as IRIS are also foundational in scaling up research or automating interpretive processes, especially in language technology contexts.

While originally developed for print-based representations that utilise varied semiotic resources, IRIS's analytical reach extends beyond the page. Crucially, because spoken language is a mode of verbal communication, the IRIS model is equally applicable to oral discourse. In fact, spoken language introduces additional layers of ambiguity—particularly through homophones that are not homographs, such as ‘whole’ and ‘hole’, or ‘symbol’ and ‘cymbal’—which pose unique interpretive challenges. Moreover, the model shows promise for even broader applications, extending beyond the verbal mode. For instance, IRIS may be useful for analysing representations that rely on sound or gesture.

Alongside its analytical utility, IRIS offers pedagogical value by highlighting the linguistic demands placed on individuals communicating within a subject. It can be applied in educational settings to support teaching, learning, and critical reflection on subject language—all of which are elaborated in this section.

LANGUAGE AND THE LEARNING PARADOX

Communication is a fundament in teaching and learning both as means and ends. A subject language model useful for analysing, discussing, and highlighting how representations must be interpreted in different senses consequently has its place in an educational context. Since subject languages serve as the medium of communication in the classroom, students' ability to engage in discourse directly affects the learning that takes place. Simultaneously, acquiring the language of each subject is itself part of learning the subject. This *dual role of language* creates a contradiction: the very linguistic representations that students are expected to learn are also required for them to participate in the learning process. This contradiction exemplifies what is known as the *learning paradox*. As Bereiter (1985, p. 202) describes it: “if one tries to account for learning by means of mental actions carried out by the learner, then it is necessary to attribute to the learner a prior cognitive structure that is as advanced or complex as the one to be acquired.” At its core, the learning paradox arises in situations where learners must grasp procedures or concepts that exceed their current level of understanding.

The implications of the learning paradox are particularly evident in disciplines where abstract representations dominate, such as mathematics and the natural sciences. In these fields, symbolic language plays a central role, and therefore, the inclusion of representations that draw on resources beyond verbal language is essential within

the IRIS model. This challenge, how learners make sense of symbolic representations, has been widely explored in mathematics education research, where such language often poses barriers to conceptual understanding. Gravemeijer (2020) describes how learners struggle to grasp symbolic representations in mathematics, even if tactile models and other representations are introduced to support learning. This issue can be understood through the lens of the learning paradox. Gravemeijer (2020, p. 221) poses a central question: How is it possible to learn the symbolisations needed to understand new mathematical concepts, if one must already understand those concepts in order to make sense of the symbolisations? IRIS addresses this paradox by making visible the interpretive moves learners engage in when encountering unfamiliar representations. By highlighting the discernments required to navigate subject-specific language and symbolism, IRIS offers a way to scaffold learners' meaning-making processes, even when they have not yet fully mastered the underlying concepts.

In mathematics and other subjects, knowledge has developed with the subject's representational systems which means that the subject knowledge is tightly bound to the use of particular representations (e.g., see Cajori 1929; O'Halloran 2008). Moreover, being acquainted with a mathematical concept means managing a fluent use of different representations of the concept (Duval 2006). Therefore it can be assumed that the ability to accurately interpret representations is tightly related to one's learning in the subject.

In the IRIS model the learning paradox clearly plays a role in discernments about the sense of a representation, based on knowledge the reader may or may not possess (see Figure 3). However, engaging in contextual cueing does, of course, also encompass use of knowledge, because the context cannot be taken into account without the knowledge needed to interpret it. In many ways, knowing a subject-specific term, requires knowing the body of language that it is attached to (cf. Godman and Payne 1981).

THE PROMINENCE OF SYMBOLIC REPRESENTATIONS IN SOME SUBJECT LANGUAGES

From a didactic perspective the dual role of language in schooling means that a focus on language in teaching can be argued for because learning the subject language is part of learning the subject, but also because a fluent use of the subject language boosts learning. In addition, especially in STEM education (Science Technology Engineering and Maths), different representations are not merely important means to visualise objects and processes, but also necessary means in problem solving, as thinking tools and manipulatives. For example, when calculus developed, a need of a symbolism for partial differentiation emerged, because existing symbols and

natural language were insufficient. This imperative role of symbolism from a historical viewpoint is summarised by Cajori: “[m]athematical symbols with all their imperfections have served as pathfinders of the intellect” (1929, p. 350).

The complexity of reading mathematical texts, which often rely on symbolism, is evident in the challenges readers encounter when attempting to articulate the basis of their comprehension. Such difficulties may indicate a limited awareness of one’s own metacognitive processes (e.g., Österholm, 2006). Metacognitive skills play a crucial role in learning and have been shown to be related to reading comprehension (Mustopa et al. 2024). Understanding representations is only one aspect of text comprehension, but it remains a vital starting point. Since metacognition requires awareness of one’s own cognitive processes, IRIS—as a model that captures the discernments that may be needed during the interpretation of representations—can serve as a valuable tool for enhancing metacognitive skills.

Having argued for the necessity of acknowledging the need for representational skills when learning a subject, the next section concretises how IRIS can be a useful means in education, both in critical discussions of communication in different subjects, and as a tool in teaching.

IRIS IN THE CLASSROOM

Besides from its use as a theoretical model in research, IRIS has didactical implications as it conceptualises the demands that are put on the reader of a subject text. Critical discussions about how various representations in subject languages are interpreted have their place, both in teacher education and for practising teachers, in analyses of ambiguous representations, examining the means by which a technical sense is communicated. IRIS can be helpful in discussions aiming to develop necessary metacognitive and metalinguistic skills for interpreting subject texts (cf. Bessy & Knouse 2020, Wass et al. 2023). By highlighting discernments someone communicating in a subject does, potential demands and sources of misunderstandings can be revealed. With such an understanding, the potential for a well-considered design of teaching is increased. Such discussions about senses of representations are worthwhile, as there is a risk for those fluent in a subject language to underestimate the number of representations in the text that are not straightforward to interpret.

The IRIS model, with its visualisation, can also be used as a tool in teaching to highlight critical aspects of subject languages. In mathematics, for example, students meet representations that at a glance seem rather similar, but whose roles differ depending on sense. For example, a discussion about the discernment of the sense of

parentheses can stress the different roles of parentheses in mathematics. IRIS can also play a role as support to a metalanguage teaching, as it highlights crucial aspects of interpreting representations. With the help of the model, learners can consciously refer to ambiguous representations and recognise their interpretation process as context-aided.

CLOSING REMARKS

The IRIS model is designed to support analysis and reflection, not to exhaustively represent all linguistic nuances. As with any theoretical model, IRIS necessarily involves a degree of abstraction and simplification. Its interpretative categories are meant to help researchers and educators to think and clearly distinguish between categories, rather than to perfectly classify every detail. However, this very abstraction also opens up possibilities for theoretical expansion.

A natural extension of the IRIS model is to incorporate the concept of *constructions*, a specific case of how context shapes interpretation. Constructions are linguistic patterns of form and meaning that are too specific to be considered universal rules, yet too general to be tied to individual words (Goldberg 2013). One example is the idiomatic way of expressing rate formulas like ‘20 dollars an hour’ (Fillmore et al. 2012). The identification of constructions is crucial in the interpretation of subject text (and other types of texts), as identifying a construction that incorporates ambiguous words for example, eliminates the ambiguity of these words – the interpretation of the construction as a whole takes precedence over the interpretation of its individual elements. Due to the overriding nature of construction-level interpretation, interpreting comprehensive constructions is a rather special case in relation to IRIS. These cases are therefore set aside for further exploration in future publications (e.g., see Dyrvold & Ribeck Nyström, submitted).

We will continue to empirically investigate potential applications of IRIS, both in research and teaching contexts. At the same time, fellow researchers and educators are encouraged to engage with and test the model in their own domains.

NOTE

- 1 We adopt the definition of a subject as an adapted representation of one or more academic disciplines, typically simplified to suit the school context (cf. Christie & Macken-Horarik 2011).

COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

- Beck, I. L., McKeown, M. G., & Kucan, L.** (2002). *Bringing words to life: Robust vocabulary instruction*. Guilford Press.
- Bereiter, C.** (1985). Toward a solution of the learning paradox. *Review of Educational Research*, 55(2), 201–226. <https://doi.org/10.2307/1170190>
- Bessy, M., & Knouse, S. M.** (2020). Metacognition, Metalinguistic Awareness, and Relevance in Language Learning: A Report on an Intervention Module Project. *IJ-SoTL*, 14(2), Art. 9. <https://doi.org/10.20429/ijsoTL.2020.140209>
- Blott, L. M., Hartopp, O., Nation, K., & Rodd, J. M.,** (2022). Learning about the meanings of ambiguous words: evidence from a word-meaning priming paradigm with short narratives. *PeerJ*, 10, Article e14070. <https://doi.org/10.7717/peerj.14070>
- Cajori, F.** (1929). *A history of mathematical notations: Vol. 2 Notations mainly in higher mathematics*. Open court.
- Christie, F., & Macken-Horarik, M.** (2011). Disciplinarity and school subject English. In F. Christie & K. Maton (Eds.). *Disciplinarity: Functional linguistic and sociological perspectives*, pp. 175–196. Continuum International Publishing Group Ltd.
- Chun, M. M., & Jiang, Y.** (1998). Contextual cueing: Implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology*, 36(1), 28–71. <https://doi.org/10.1006/cogp.1998.0681>
- Cirillo, M., Richardson Bruna, K., & Herbel-Eisenmann, B.** (2010). Acquisition of mathematical language: Suggestions and activities for English language learners. *Multicultural Perspectives*, 12, 34–41. <https://doi.org/10.1080/15210961003641385>
- Cummins, J.** (1981). Age on arrival and immigrant second language learning in Canada. A reassessment. *Applied Linguistics*, 2, 132–149. <https://doi.org/10.1093/applin/II.2.132>
- Cummins, J.** (2000). *Language, power and pedagogy: Bilingual children in the crossfire*. Multilingual Matter. <https://doi.org/10.21832/9781853596773>
- Duval, R.** (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, 61(1/2), 103–131. <https://doi.org/10.1007/s10649-006-0400-z>
- Dyrvold, A., & Ribeck Nyström, J.** (submitted). Solving ambiguity in mathematics text.
- Fillmore, C. J., et al.** (2012). The FrameNet construction. In H. C. Boas, & I. A. Sag (Eds.), *Sign-Based Construction Grammar* (pp. 309–372). CSLI Publications.
- Godman, A., & Payne, E. M. F.** (1981). A taxonomic approach to the lexis of science. In L. Selinker, E. Tarone, & V. Hanzeli (Eds.), *English for academic and technical purposes: Studies in honor of Louis Trimble* (pp. 23–39). Newbury House.
- Goldberg, A. E.** (2013). Constructionist approaches. In T. Hoffmann & G. Trousdale (Eds.), *The Oxford Handbook of Construction Grammar* (15–31). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780195396683.013.0002>
- Gravemeijer, K.** (2020). A socio-constructivist elaboration of realistic mathematics education. In *ICME-13 monographs*. Springer International Publishing AG. pp. 217–233. https://doi.org/10.1007/978-3-030-33824-4_12
- Hulstijn, J. H.** (2011). Language proficiency in native and non-native speakers: an agenda for research and suggestions for second-language assessment. *Language Assessment Quarterly*, 8, 229–249. <https://doi.org/10.1080/15434303.2011.565844>
- Jourdain, L., & Sharma, S.** (2016). Language challenges in mathematics education: A literature review. *Waikato Journal of Education*, 21(2), 43–56. <https://doi.org/10.15663/wje.v21i2.269>
- Kortmann, B.** (2020). Pragmatics: The study of meaning in context. In: *English Linguistics*, J. B. Metzler, Stuttgart. https://doi.org/10.1007/978-3-476-05678-8_7
- Lemke, J. L.** (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. R. Martin, & R. Veel (Eds.), *Reading Science* (pp.87–113). Routledge.
- Monroe, E., & Panchyshyn, R.** (1995). Vocabulary considerations for teaching mathematics *Childhood Education*, 72, 80–83. <https://doi.org/10.1080/00094056.1996.10521849>
- Moschkovich, J. N.** (2015). Scaffolding student participation in mathematical practices. *Zdm*, 47(7), 1067–1078. <https://doi.org/10.1007/s11858-015-0730-3>
- Mustopa, R. A., Damaianti, V. S., Mulyati, Y., & Anshori, D. S.** (2024). Investigating senior high school students' metacognition in Indonesian learning reading comprehension: does it have a positive impact? *IJoLE (International Journal of Language Education)*, 8(2). <https://doi.org/10.26858/ijole.v8i2.64112>
- Nation, I. S. P.** (2001). *Learning vocabulary in another language*. Cambridge University Press. <https://doi.org/10.1017/CBO9781139524759>
- O'Halloran, K. L.** (2008). *Mathematical discourse: language, symbolism and visual images*. Continuum.
- Österholm, M.** (2006). Metacognition and reading – criteria for comprehension of mathematics texts. In J. Novotná, H. Moraová, M. Krátká, & N. Stehlíková, (Eds.), *Proceedings of the 30th conference of the International group for the psychology of mathematics education* (Vol. 4, pp. 289–296), Prague: PME. <https://www.diva-portal.org/smash/record.jsf?pid=diva2:22665>

- Parszyk, I.-M.** (1999). *A school for others. Minority students' experiences of their working and living conditions in the Swedish compulsory school*. Diss. Studies in Educational Sciences 17. Stockholm University.
- Pimm, D.** (1987). *Speaking mathematically: Communication in mathematics classrooms*. Routledge.
- Ribeck, J.** (2015). *Step by step. A computational analysis of Swedish textbook language*. Diss. Data linguistica 28, University of Gothenburg. <http://hdl.handle.net/2077/40506>
- Ribeck Nyström, J., & Dyrvold, A.** (2019). *Subject language in mathematics textbooks*. Verbal text fragments supplemented by other semiotic resources. ECER 2019, 3–6 September, Hamburg, Germany.
- Roberts, N. S., & Truxaw, M. P.** (2013). For ELLs: Vocabulary beyond the definitions. *The Mathematics Teacher*, 107(1), 28–34. <https://doi.org/10.5951/mathteacher.107.1.0028>
- Schleppegrell, M.** (2007). The linguistic challenges of mathematics teaching and learning: A research review. *Reading & Writing Quarterly*, 23, 139–159. <https://doi.org/10.1080/10573560601158461>
- Shanahan, T., & Shanahan, C.** (2008). Teaching disciplinary literacy to adolescents: rethinking content-area literacy. *Harvard Educational Review* 78(1), 40–59. Spring 2008. <https://doi.org/10.17763/haer.78.1.v62444321p602101>
- Shanahan, T., & Shanahan, C.** (2012). What is disciplinary literacy and why does it matter? *Top Lang Disorders*, 32(1), 7–18. <https://doi.org/10.1097/TLD.0b013e318244557a>
- Sibold, C.** (2011). Building English language learners' academic vocabulary: strategies and tips. *Multicultural Education*, 18, 24–28.
- Simpson, A., & Cole, M. W.** (2015). More than words: A literature review of language of mathematics research, *Educational Review*, 67(3), 369–384. <https://doi.org/10.1080/00131911.2014.971714>
- Tabossi, P.** (1989). What's in a Context? In D. S. Gorfein (Eds.), *Resolving semantic ambiguity*, pp. 25–39. Springer. https://doi.org/10.1007/978-1-4612-3596-5_3
- Wass, R., Rogers, T., Brown, K., Smith-Han, K., Tagg, J., Berg, D., & Gallagher, S.** (2023). Pedagogical training for developing students' metacognition: implications for educators, *International Journal for Academic Development*. <https://doi.org/10.1080/1360144X.2023.2246442>

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