

Mental Model Theories in Reading Research and Instruction

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Abstract This chapter looks at expository text models and the way they are applied in foreign language (FL) research and teaching. First, a short history of how mental model perspectives developed is presented. The characteristics of the Kintsch (1974) model, an example of an earlier model, are discussed. It is emphasized that unlike earlier models, which examine the connection of text structure with text memory but fail to account for how readers comprehend expository texts, the more recent approaches focus on the construction of comprehension, i.e., they account for mental representations of text and describe and explain the processes that are involved in this construction. As an example of a more recent mental model of reading, Britton's (1994) grammar of exposition is discussed. Its usefulness in reading comprehension studies is elucidated. As an example of such research, the study conducted by the author of the paper is presented. The paper ends with some suggestions concerning the use of the model in pedagogy, particularly in relation to developing FL learners' awareness of text structure and enhancing the understanding of the writer's strategies to express meaning.

1 A Short History of Mental Model Perspectives

Reading research is a little more than one hundred years old. Over that time it has shifted from studies of remembering lists of words to comprehension of sentences and finally to the mental processes of comprehending coherent texts. Studies investigating reading processes at the beginning of the 20th century focused on reading rates and the eye-voice span. Although most research of that time was

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concerned with motor processes, more and more attention was paid to mental processes of reading. In the early 1970s a number of studies concerning text analysis appeared. The studies of Kintsch (1974), and Meyer (1975), among others, provided evidence that the comprehension process is affected by text structure.

The Kintsch (1974) model focuses entirely on reading comprehension processes, excluding the word identification stage. The key notions of the model are propositions, which may be defined as “ideas that can be expressed in words, not the words themselves” (McNamara, Miller, & Bransford, 1991, p. 342). During their studies Kintsch and Keenan (1973) observed very high correlations between reading times and numbers of propositions, not numbers of words in sentences.

According to the Kintsch (1974) model, processing the text is done automatically in cycles due to limited memory capacity. Comprehension operates at two different semantic levels: the *micro level*, referring to the local discourse of the text, and the *macro level*, referring to the more global discourse of the text. An important role is assigned to the reader’s schema knowledge, which represents his/her goals and expectations. The schema controls text comprehension and selects micropropositions relevant to the gist of the text, which at the highest level of comprehension are transformed into one macroproposition (which might be, for example, the title of the text). In fact, Kintsch and van Dijk (1978) demonstrated this effect in the study of recall after reading. They showed that what was recalled 30 days later was only the summary-type information represented as macroproposition(s) in the model.

The model also accounts for the situation when no connections can be found between text propositions, and new propositions are inferred to make the text coherent and facilitate its comprehension. In comparison with other models, the Kintsch model provides a much more complex account of text comprehension at high levels, those not requiring decoding.

In time the theory of reading based on propositions met with criticism. It was noticed that “a problem with propositional representations is that they are often more representative of the structure of the text than they are of the structure of memory for the text” (McNamara et al., 1991, p. 492). The importance of the reader’s prior knowledge in reading comprehension came to light again (e.g., Minsky, 1977; Schank & Abelson, 1977). The activation of appropriate knowledge facilitating the organisation of new information in the process of text comprehension was enquired into again. The schema theory also began to be criticised. Certain limitations of the theory were noticed and the question of why and how readers understand texts about unfamiliar events was raised (e.g., by Johnson-Laird, 1983).

Thus, a need arose for a more general approach viewing reading as a process of building and maintaining comprehension of situations described in a text. Such an approach was suggested by mental model theories. According to McNamara et al. (1991), a mental model built by the reader in the process of reading consists of “mental tokens arranged in a structure that depicts the situations described by a text” (p. 494). Mental model theories are characterised in more detail in the next section.

2 Characteristics of Mental Model Theories

Mental model theories draw on the theoretical premises of propositional models and schema models. They view reading as a process of building and maintaining comprehension of the situations described in a text. They enrich the view of text representation suggested by the earlier models, such as the Kintsch (1974) model and Meyer's (1975) system. Text representation is not based entirely on the text. McNamara et al. (1991) say that "readers not only process a text at a propositional level, but also construct a mental model that is analogous in structure to the events, situations or layouts described by the text" (p. 493). Therefore, the reader's knowledge and the strategies he/she applies are also considered important in the process of comprehension. For example, in the van Dijk and Kintsch (1983) model text information is represented in memory at three levels: surface form, propositional textbase and situation model. The *surface form* refers to the representation of the exact wording and syntax; the *propositional textbase* corresponds to a multi-leveled, locally coherent propositional network of semantic text information; and the third level, the *situation model*, depicts real-life situations presented in the text, as perceived by the reader, i.e., the reader's interpretations of the text. Other examples of mental models are: the van Dijk and Kintsch (1983) model, the construction-integration model developed by Kintsch (1988, 1998), Britton's (1994) grammar of exposition and the Gernsbacher (1996) model.

3 Britton's Model—Inducing Understanding by Exposition

Britton's (1994) grammar of exposition will be discussed in more detail below. Its theoretical assumptions and the research evidence that supports these assumptions will be presented.

3.1 Description of the Model

Britton (1994) claims that "[e]xpository texts are intended to build a structure in the readers' mind" (p. 641). The writer guides the reader by providing instructions that will enable the reader to construct the correct structure of the text and concepts that the reader can use to develop the intended structure. The reader's role is to recognize and execute the text instructions, use the concepts provided by the text and add any building material not provided by the author. Britton (1994) suggests that "the mental structures that readers derive from a text often will be incomplete or incorrect, when compared to the structure intended by the author" (p. 644).

To signal a development of ideas in the text, the author of an expository text makes certain moves, or structure building signals. Britton (1994) claims that “[a] large part of the responsibility for making the author’s moves evident is carried by a standard grammar of exposition” (p. 646). The role of the reader is to parse the text, i.e., to identify relations between units of exposition.

The most basic expository move is the *expand* move, which develops the topic of the discourse. It occurs at the topmost injunction of exposition, where the idea to be expanded on is the overall subject of the text, often expressed in the title. It also occurs at the middle levels, e.g., in a heading of the section, where the subject of comprehension is expressed as well. The most common and important, although the most complex move, is the *enlarge-on*. It occurs at the lower levels of exposition, where the information introduced in the previous sentences is developed. The *enlarge-on* is often followed by a *move-on* (which can take the form of a *move-down*, a *move-up*, a *move-across* or a *move-out*), encouraging the reader to develop his/her understanding of the text. In the text the *move-on* instruction is signalled by such phrases as: “moving on to”, “our next topic is”, “turning to”; it can also be indicated by the period at the end of the sentence or by a new heading of the section. Britton distinguishes two more signals—the *unitise* and the *stop*. The role of the *unitise* is to instruct the reader to work out the hierarchy of the structures of the representation of the text, to construct macropositions (cf. Kintsch & van Dijk, 1978), or in other words to form a conclusion and to summarise a section of the text. This operation can be signalled by phrases such as “in summary” and “the point is”. The last move, the *stop*, brings the discourse to an end and instructs the reader to stop reading and constructing his/her representation.

Britton compares the nature of the signals left by the writer in expository texts to the linguistic notions of speech acts. All of them include both information concerning the subject developed by the text and instructions about actions that the reader should perform to insert this information properly into his/her mental representation. However, the structure-building injunctions are very rarely expressed directly; most often they are indirect or absent. The most direct instructions are phrases that do not contain information about the topic of the text, but information that instructs the reader about what he/she should do with the information about the text. Examples of such phrases are “for example”, “in summary” and “the second point is”. Another way to help the reader to construct the structures intended by the writer is to use various paralinguistic devices, such as text layout, and mixed linguistic physical signals such as punctuation, paragraph indentation, headings and their position, size of font, colour, and so on.

3.2 Accounting for Pathologies of Expository Text

An unquestionable advantage of Britton’s model is his attempt to account for difficulties the reader may encounter when reading expository texts, in other words to explain why the writer can produce a text that fails to guide the reader. Britton

(1994) claims that “one underlying explanation for these widespread failures of expository text is certain illusions which are characteristic of the subject matter experts who write expository text” (p. 661). Experts in the subject matter of their texts usually begin to produce texts with a mental structure for the subject matter area that tends to be highly structured and well-developed. Their expert knowledge is also highly proceduralised and automatic, and therefore opaque even to experts themselves. As a result the text the expert produces can be too dense for non-expert readers. The rate at which the expert-writer develops his/her exposition may be too fast for the novice to follow, which may result in a lack of propositions and links that the non-expert would need. In terms of a grammar of exposition, the expert-writer tends to move on too fast; he/she may introduce new information too quickly, without overlap clues and unitise instructions, which would make the text more understandable for the non-expert reader.

4 Mental Models in Research—an Overview of Studies

This section presents an overview of studies inspired by mental model theories. Mental model theories seem to be supported by studies of the mental processes that occur during reading. For example, Garnham (1981) found that readers choose whether to focus on propositional or mental model processing. When the subjects were not warned about a memory test following the reading, they seemed to process the texts as mental models. They had difficulty recalling exact sentences and distinguishing between sentences present in the text and those that had not appeared there. Their recall seemed to reflect a mental representation of the text, rather than the propositional one.

A number of psycholinguists have tried to develop a mental model for narrative texts. Morrow (1985) observed how kindergarten children read narrative texts. The researcher noticed that when readers are actively engaged in reading, they maintain a mental model of the text during reading, e.g., by focusing on relevant characters in a narrative. Another conclusion drawn from the study was that mental model processing seems most predominant in certain types of texts, e.g., narrative texts and spatial descriptions.

Barnes, Raghubar, Faulkner and Denton (2014) looked at how adults and children updated their spatial situation models when reading a narrative text. The results underlined the importance of both explicit text-based information and a mental model of the real-world situation described in the text. However, it was the ability to develop the situation model that was found to be predictive of reading comprehension.

Mental model theories also attempt to account for individual differences in reading comprehension, particularly differences between good and poor readers. For example, Merrill, Sperber, and McCanley (1981) found that good readers differ from poor ones in that they seem to prioritise different text properties. Good readers appear to be more sensitive to contextually relevant text properties, while poor

readers do not distinguish relevant from irrelevant text properties. This over-reliance on irrelevant text properties can hinder understanding of important relationships between ideas in the text. Since a large part of reading comprehension seems to depend on the construction of appropriate mental models, mental model researchers claim it is vital to find ways of instruction that will focus on the construction of meaning of the text. Context seems to be an essential factor in developing efficient, skilled reading.

Another issue investigated concerned reading comprehension difficulties. Woolley (2011) in his extensive discussion of problems that children can encounter in reading comprehension views the construction of a text-based model and a situation-model as fundamental cognitive processes in the reading process. The researcher draws on Kintsch's (1988) theory and Meyer's (1975) research and stresses the impact of text variables in comprehension difficulties, concluding that "coherence within the text and the theme of the story are critical in the readability of text" (Woolley, 2011, p. 25).

Mental model theories have also contributed to contrastive studies, i.e., those that explore differences between the first language (L1) and foreign language (FL) reading. Jenkin, Prior, Richard, Wainwright-Sharp, and Bialystok (1993) found that readers were able to form propositional relations and develop mental models in their L1. However, in their FL only propositional networks were developed. The researchers concluded that the content information is represented differently in text memory during L1 and FL processing.

Mental model perspectives allow researchers to examine the comprehensibility of expository texts, e.g., textbooks, and correlate it with students' reading comprehension. It is assumed that instructions provided by textbook writers may not be sufficient for students to build the intended mental structure concerning the subject discussed in the text. An example of this kind of research is a study conducted by Britton and Gülgöz (1991). Drawing on the Kintsch and van Dijk model (1978), the researchers modified the original text and prepared a version that apparently reflected the author's intentions better than the original text. Then they examined the reading comprehension of 170 undergraduate students and observed a significant increase in the students' free recall of the improved version when compared with that of the original text.

5 A Think-Aloud Study of Reading Expository Texts

Britton's model of exposition has also provided inspiration for the think-aloud study conducted by the present author (Kusiak, 2013). In this study Britton's model was used for the following purposes: (1) to analyse the texts read by the subjects, and (2) to analyse how the students constructed their representations of the texts. Below only the stages of the study in which Britton's model was applied are discussed. The results of the study are not presented; they can be found in Kusiak (2013).

5.1 The Goal of the Study

The main aim of the study was to compare the reading comprehension of proficient readers of Polish (L1) and advanced readers of English (FL), when reading expository texts in their native language (Polish) and in a foreign language (English). The following research questions were asked:

1. Do proficient readers of Polish (L1) and advanced readers of English (FL) read in the same manner in their L1 and FL? and
2. If they do not, what is the difference in the way they read in Polish and English?

5.2 The Subjects

The subjects were 10 undergraduate students in a foreign language teacher training college: 6 women and 4 men. Their language competence was assessed as advanced (i.e., C1 according to the *Common European Framework*). The author of the study was their teacher and it was assumed that the students would feel comfortable with the researcher during the think-aloud session.

5.3 The Materials

The texts were authentic news magazine articles: a Polish one taken from *Newsweek* (the Polish edition) and an English one from *Time*. The English text, entitled “*Is progress obsolete?*”, addresses the issue of progress, its advantages and limits; whereas the Polish text “*Materia ducha*” asks philosophical questions concerning the dichotomy of brain and soul. It was assumed that the topics would encourage the students to read the texts. The Polish text consists of 9 paragraphs; whereas the English text has 10 paragraphs. Both were accompanied by photos. Since the pilot study had showed that the task of reading complete texts could be too tiring for the subjects, the students were asked to read the first 6 paragraphs in the Polish article and the first 7 paragraphs in the English article.

5.4 The Analysis of the Texts

In order to ensure the validity and reliability of the study, the two texts read by the subjects were analysed and compared. In each text clues left by the author of the text for the reader were analysed and types of moves identified. Below an extract taken from the Polish text (the title, subtitle and the first paragraph) is presented along with an exact translation of the text. Table 1 presents the analysis of this extract.

Table 1 Analysis of the beginning of the Polish text

Moves	Fragments of the text	Clues in the text for the reader
EXPAND	<i>Materia ducha</i> <i>The material of the spirit</i>	– Introducing the idea of the material of the spirit
ENLARGE ON Move down ("ducha"—"spirit")	<i>Neurobiologia nauczyła się badać to, co nazywamy duszą. Trzeba odrzucić dogmaty i skorzystać z tej szansy</i> <i>Neurobiology has learnt how to examine what we call the soul</i> <i>Dogmas need to be rejected and the opportunity taken</i>	– An idea overlap of the ideas expressed by "dusza" and "duch" ("soul" and "spirit") – Introducing the idea of neurobiology – Introducing the idea of dogmas – "tej szansy" ("the opportunity") refers the reader to the previous sentence
Move down ("duch"—"spirit") Move out (Descartes' theory about body/mind dualism)	<i>W sposób naturalny wierzymy w mit kartezjański, wedle którego naszym ciałem kieruje duch, dokonujący wyborów niezależnie od uwarunkowań biologicznych</i> <i>We believe in the Cartesian myth in a natural way, according to which our body is controlled by the spirit, undertaking choices independent of biological conditions</i>	– Indirect reference to "dogmaty" ("dogmas") – Introducing the idea of the common belief about dualism between the spirit and the body
Move down ("mit kartezjański"—"Cartesian myth") Move up ("dogmaty"—"dogmas")	<i>Przyjmujemy za pewnik: mózg jest z materii, a duch z pierwiastka niematerialnego</i> <i>We take it as certain that the brain is of matter while the spirit of a non-material element</i>	– Extending the idea of the Cartesian myth – The use of "przyjmujemy" ("we take") invites the reader to draw on his/her common knowledge and stresses the fact that this view is shared by other people
Move down ("przyjmujemy"—"we take as certain")	<i>Zgadzamy się oczywiście, że mózg bierze udział w życiu umysłowym, ale wciąż traktujemy go jak kieszonkowego peceta naszej duszy, który w imieniu "duchowego użytkownika" przetwarza i zarządza informacjami</i> <i>We agree of course that the brain takes part in mental life, yet we continually treat it as the pocket-size PC of our soul, which in the name of "the spiritual user" processes and manages information</i>	– Reference to "przyjmujemy" ("we take") – "ale" ("yet") presents a contradiction in our thinking, the idea that although we accept the principles of Descartes' dualism, we still treat the brain as part of the spirit

Table 2 Comparison of the two texts used in the study in terms of the number of moves identified

Type of move	Polish text	English text
Expand	13	7
Move down	12	17
Move up	12	22
Move out	1	1
Unitize	0	2

MATERIA DUCHA
NEUROBIOLOGIA NAUCZYŁA SIĘ BADAĆ TO, CO NAZYWAMY DUSZĄ.
TRZEBA ODRZUCIĆ DOGMATY I SKORZYSTAĆ Z TEJ SZANSY.
STEVEN PINKER
1/W sposób naturalny wierzymy w mit kartezjański, wedle którego naszym ciałem kieruje duch, dokonujący wyborów niezależnie od uwarunkowań biologicznych. Przyjmujemy za pewnik: mózg jest z materii, a duch z pierwiastka niematerialnego. Zgadzamy się oczywiście, że mózg bierze udział w życiu umysłowym, ale wciąż traktujemy go jak kieszonkowego peceta naszej duszy, który w imieniu “duchowego użytkownika” przetwarza i zarządza informacjami.
THE MATERIAL OF THE SPIRIT
NEUROBIOLOGY HAS LEARNT HOW TO EXAMINE WHAT WE CALL THE SOUL
DOGMAS NEED TO BE REJECTED AND THE OPPORTUNITY TAKEN
STEVEN PINKER
1/We believe in the Cartesian myth in a natural way, according to which our body is controlled by the spirit, undertaking choices independent of biological conditions. We take it as certain that the brain is of matter while the spirit of a non-material element. We agree of course that the brain takes part in mental life, yet we continually treat it as the pocket-size PC of our soul, which in the name of “the spiritual user” processes and manages information.

The analysis of each text, which involved identification of moves, was followed by a comparison of one with the other. The comparison of the moves identified in the two texts is presented in Table 2.

The results of the analysis show some differences between the texts. In the Polish text 13 new ideas were introduced throughout the article, whereas in the English text 7 new ideas were introduced (this is reflected in the number of “expand” instructions). The English text has more move-down and move-up instructions than the Polish text. Another difference lies in the number of unitize moves; there are two such moves in the English text and no moves of this kind in the Polish text. There is no difference in the number of move-out moves. The analysis shows that the Polish text has a more “dense” network of ideas, which can make it more difficult for the reader. The texts seem to reflect two different ways of developing exposition of ideas, a characteristic of argumentative written texts produced in Polish and English respectively, a feature which is accounted for by the principles of contrastive rhetoric and has been investigated, e.g., by Yakhontova (2002) and Salski (2012).

Table 3 Analysis of a think-aloud protocol of one of the subjects when reading the introductory part and the first paragraph of the Polish text. Taken from Kusiak (2013, pp. 157, 158)

Section in the text	Propositions formed during reading	Think-aloud reports
The introductory part	• A soulless egghead, he has the brain in his grasp and doesn't believe in the soul? • Why is he holding the brain? • The material of the spirit • Neurobiology	First I'm looking at the picture, I'm ignoring the text. I'm looking at the picture and reading (the caption below the picture) "A soulless egghead" uhm, it's intriguing, "he has the brain in his grasp and doesn't believe in the soul". Why? And why is he holding the brain in his hand? T: Is he? S: Yes, he is. And the brain in this.. Oh, my God! This is so interesting for me! (laughter) "The material of the spirit", yes. Uhm, well and right away I associate it with (...), when I looked at this text, I looked, yes, at "The material of the spirit", at the picture, at the caption and at "neurobiology". (.) And that's all. And now I'm reading T: What are you reading? S: Well, so "The material of the spirit" and this subtitle "neurobiology". (...) Right, well (...) I found it very interesting xx this statement of this Steven uhm about the brain (.) But how can we treat the brain as a PC of our soul? I understand a PC is a computer, but (.) I don't know but I don't treat the brain as a PC of our soul. It's so strange for me, I can't agree with this. (.) And it's also interesting, yes, it's interesting, the beginning of the article is interesting. Now I continue reading T: What did you pay attention to when you were reading? S: Right, it caught my attention earlier; that the Cartesian myth, which means that we have separate, that is the body is directed by the spirit, which functions, yes I understand it OK, and this is so eh (.....) I think that the article is about, about the role of the soul and what is the soul and what, eh, how we define the brain. And here they say that the soul directs our body and the brain is made of substance, and the soul is immaterial, which means that a distinction between these two things which are different. (...) And now it seems to me that the next paragraph will be about, uhm e.g., how the brain influences the soul, if it's possible, and how the soul, yes how the soul directs our body so that the brain listens to it, obeys it. And I'm wondering why this brain is a PC of our soul, it's a computer – what does it mean? Xx a computer and now I'm thinking (.) Why here, why is there the word "a computer", I don't understand this phrase, how can it be the pocket computer of our soul? so what does it mean? Does it mean that in this computer we can find everything? and it is the question that I'm wondering about. (...) And what xx in our soul and now I have such strange thoughts, and then it goes: "which in the name of its 'spiritual user' processes and manages information." So does it mean that the brain and the soul sort of cooperate with each other. And I'm wondering how it will develop, what is the connection between the brain and the soul from the point of view of neurobiology. I know from the subtitle that "Neurobiology has learnt how to examine what we call the soul" and this is interesting. And now I go on reading
The 1st paragraph	• The material of the spirit? • Neurobiology? • We treat the brain as the pocket-size PC of our soul? • According to Descartes our body is controlled by the spirit • Brain is made of material substance and soul of non-material substance • The brain influences the soul? The soul guides the body? The brain is guided by the soul? • The brain is our PC? • The brain is a pocket computer? • Body and soul can cooperate? • How is the connection between body and soul investigated by neurobiology?	

5.5 *The Analysis of How the Students Constructed Their Representations of the Texts*

In this analysis, propositions in the students' representations of the texts were identified. At this stage of the study, the term "proposition" was used both in the analysis of the text and the analysis of students' protocols. It was accepted that it refers to text units (in the text analysis) and the ideas the students constructed on the basis of the text (in the analysis of think-aloud protocols). Table 3 presents the analysis of a think-aloud protocol of one of the subjects, in which the reader read the introductory part and the first paragraph of the Polish text. The table shows a transcription of a think-aloud report and the corresponding propositions which were identified in the think-aloud reports.

Two types of propositions were identified in the think-aloud protocols and named partial and final. *Partial propositions* (marked as interrogative statements in think-aloud protocols) are those that the students formed very often at the beginning of the construction of their representations concerning the particular parts of text. They reflect the readers' tentativeness or uncertainty concerning their comprehension as well as strategies that helped the readers to modify their propositions before accepting them and incorporating them into the final version of their comprehension. *Final propositions* (marked as affirmative statements) were the propositions about which the subjects did not report doubts. It is worth emphasising that they also underwent changes; in many cases the readers elaborated on the propositions, e.g., by adding new propositions to them, thereby constructing more complex representations of the text. It is important to stress that the analysis of propositions constructed by the students provided the basis for the subsequent stages of the study.

To sum up, the aim of this section was to demonstrate the advantages of using mental model theories in reading studies. It seems that mental model perspectives can contribute to the conceptualization of reading and provide researchers with a useful tool to analyse texts used in studies as well as to investigate the text comprehension processes of the subjects under investigation.

6 Conclusion and Teaching Implications

Mental models have a number of advantages. In contrast to the earlier models, e.g., Meyer's (1975) system or the Kintsch (1974) model, they elucidate dynamic relationships between text structure properties and the reader's background knowledge. They focus on both the writer and the reader, describing the strategies that the writer applies to communicate his/her ideas as well as factors that influence the reader's construction of text representation.

As the earlier discussion demonstrates, mental model theories have been applied in numerous studies that aim to explain the communication between the reader and the writer. Additionally, they offer interesting implications for both L1 and FL/L2

reading instruction. Since they are useful in analysing texts, they contribute to discussions on the simplification/authenticity as well as comprehensibility of written texts, issues which are important for both researchers and teachers.

Mental model theories can also inspire teachers, particularly those of advanced foreign language learners, to design activities to sensitise students to text structure. As regards writing, such activities can show learners how to plan their texts and how to leave clues for the reader of their texts or in other words how to be a responsible writer. By analysing texts, e.g., by means of the Britton model, students can learn how to approach texts strategically and how to search for clues provided by the writer, which means learning how to be a “skilful” reader. Think-aloud techniques seem to be of help in facilitating development of learners’ mental models, since as Sweet and Snow (2003) claim “understanding at the level of the mental model has particularly important implications for comprehension, because this is the level at which many readers struggle” (p. 90).

Undoubtedly, there is a need for more research into the usefulness of mental model theories in both reading studies and pedagogy.

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