Learning from texts : extending and revising knowledge

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CHAPTER 1

General Introduction

Introduction

Learning environments have undergone great changes in the past decades. One of the most striking changes is the digitalization of learning materials. Paper texts are still important sources of information, but students nowadays also have access to an almost unlimited amount of digital texts that are available through the Internet. Reading comprehension skills are necessary to be able to learn from these texts. Students need to understand each individual text, and select and integrate information from multiple sources in order to construct a mental representation of the topic. These skills are not new, but what *is* new is that they have become more important in school settings, professional environments and personal situations than they were in the past (Common Core State Standards, 2010; National Research Council, 2012; NRO, 2016; OECD, 2015). Although the availability of information enables more learning opportunities, it also increases the risk of learning incorrect information because sources can be unreliable, biased, or incomplete (Britt & Rouet, 2011). Again, this is not a new challenge for students and teachers, but it has become more important than before due to easier access to incorrect information.

In response to the educational challenges that are the result of the increasing availability of information, many governmental institutions have adapted the national educational standards by putting more emphasis on integration skills and skills involved in revising inaccurate knowledge, with the aim of improving learning materials, assessment, and instruction (Common Core State Standards, 2010; SLO, 2006). Only a few studies have been conducted to assess the ability to integrate information across multiple sources, but the little that is known suggests that the educational standards concerning integration across texts are not met yet. For example, two reports show that children struggle with tasks requiring integration of multiple texts (Sabatini, O'Reilly, Halderman, & Bruce, 2014; Sheehan, Kostin, & Persky, 2006).

The purpose of the current dissertation is to gain insight into the processes that are involved in learning from (multiple) texts in adults and children. Behavioral data were collected of the learning process and the resulting knowledge representation. In addition, the effects of individual differences in reading comprehension ability and working memory were considered. Before describing the individual chapters of this dissertation, a brief overview of the topic learning from texts is provided. In this overview two types of learning conceptual knowledge are differentiated; learning that results in *extending* conceptual knowledge and learning that results in *modifying* incorrect conceptual knowledge (van den Broek, 2010).

The Expansion of Knowledge

One form of learning is *extending* knowledge[1] about a certain topic by reading texts. This process starts with processing texts and must eventually lead to the construction of a coherent mental representation of the information in long-term memory (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; Trabasso, van den Broek, & Suh, 1989; van den Broek, Risden, Fletcher, & Thurlow, 1996). Although comprehension is necessary for constructing knowledge representations from texts (Donovan & Bransford, 2005; Glynn & Muth, 1994), it is not always sufficient to create a *permanent* representation of the topic. For instance, information that has been encountered in a text and comprehended may not be recalled at a later moment in time. This may happen due to failure to encode information from the text permanently or due to failure to recognize that text information encountered earlier is relevant in a new context. It is not clear which processes contribute to the construction of a permanent knowledge representation that can be applied in different contexts (i.e. a knowledge representation that is decontextualized). This is largely because in the past research has focused predominantly on 1) assessing what is remembered shortly after reading, which does not necessarily reflect the permanency of knowledge in memory after a longer time interval, and 2) processing narratives, which are rarely used in formal learning situations (Lorch, 2015), and 3) processing single texts, which does not necessarily contribute to the decontextualization of knowledge (Lobato, 2006).

Knowledge extension usually occurs as a result of multiple learning experiences, for example through reading multiple texts (e.g. from books, news articles, websites, etc.). Research is relatively limited, but insights concerning this topic are gradually increasing (Bråten, Britt, Strømsø, & Rouet, 2011; Britt & Rouet, 2011, 2012). A central issue is *how* multiple texts are integrated in a single knowledge representation. The links between texts are often implicit and it is the reader's task to connect different sources of information in order to create a complete knowledge representation. This is not an easy task, because the boundaries between multiple texts can be large (Britt, Rouet, & Braasch, 2013). For example, texts may lack in content overlap (Britt, Perfetti, Sandak, & Rouet, 1999; Kurby, Britt, & Magliano, 2005), texts may be processed at different times and in different locations, or texts may be inconsistent with each other (Stadtler & Bromme, 2014). It is therefore important to address which cognitive processes are involved in integrating information across multiple texts. One such process is activation of information from previous texts during reading.

[1] In this dissertation knowledge refers to information that can be represented by at least one idea unit and that is encoded in memory.

If readers activate information from previously processed texts during reading and recognize that this information is related to the current text, connections between different texts can be established (Goldman & Varma, 1995; Kendeou & O'Brien, 2014; McRae & Jones, 2013; van den Broek, Risden, et al., 1996). Activation of prior text information is crucial for integration within texts (Kendeou, Rapp, & van den Broek, 2003), and may be crucial for integration *across* texts as well (Britt et al., 1999; C. A. Perfetti, Rouet, & Britt, 1999).

The Development of Integration Skills

As children move up the grades, they are supposed to connect information within increasingly extensive texts and between an increasing number of texts (Hatcher, 2000; Mesmer, Cunningham, & Hiebert, 2012). Children are hardly ever included in research about integration across texts (but see Wolfe and Goldman (2005) for an exception) and research concerning the development of skills involved in integrating information across multiple texts is absent. In contrast, the development of inferencing skills *have* been studied and given that certain types of inferences require integration skills (e.g. text-connecting inferences) these findings possibly generalize to the development of integration across texts. More specifically, it has been demonstrated that children improve their ability to make inferences as they get older (Oakhill & Cain, 2012; Oakhill, Cain, & Bryant, 2003). Generalizing these findings to integration of information across texts should reveal similar developmental patterns.

In part, developmental improvements in the ability to integrate information may be driven by the development of working memory (Cain, Oakhill, & Bryant, 2004; Seigneuric & Ehrlich, 2005) which is strongly related to learning (Cowan, 2014). Working memory is a cognitive function that allows one to temporary store and process information. The development of working memory may enable developing readers to temporarily store and process more information at the same time, across larger distances, which may result in more complex and elaborate knowledge representations of the texts (Daneman & Carpenter, 1980).

The Modification of Knowledge

Another form of learning is *modifying* existing (incorrect) knowledge (i.e. misconceptions). Misconceptions are quite common among students of all ages, either as a result of naïve conceptions of the world (e.g. "The Earth is flat, because the horizon looks flat") or as a result of exposure to unreliable sources (e.g. repeated exposure to the image of an ostrich putting its head in the ground

in cartoons). Exposure to unreliable sources has become a bigger issue due to the advent of the Internet, which allows fast and effortless distribution of unreliable information. Many websites make no attempt to check the reliability of information. The increased availability of inaccurate and unreliable information is a worrisome development as misconceptions have been shown to be quite pervasive (Carey, 2009; Chi, 2005; Novak, 1988; Vosniadou & Brewer, 1992).

A central question is therefore how information should be transmitted to students to accomplish knowledge revision. Because texts are one of the most common ways of delivering information, several studies investigated how texts need to be structured to accomplish knowledge revision in students with misconceptions. Traditionally, misconceptions are targeted by providing students with a text with the correct information. In this text the incorrect background knowledge is usually ignored. The rationale behind this approach is that mentioning the correct information strengthens this information in memory, which makes it more likely that the information will be recalled in the future. However, simply explaining the correct information without referring to the misconception may cause comprehension problems, because the correct information in the text does not match prior knowledge. For example, students who believe that seasons are caused by the distance of the Sun towards the Earth may be confused when reading that seasons are caused by the tilt of the Earth towards the Sun. As a result, these students may not encode the correct information about the tilt in memory because it makes their representation incoherent (Maier & Richter, 2013; Stadtler, Scharrer, & Bromme, 2012).

Another way to accomplish knowledge revision is by using a refutation text format: The incorrect information is explicitly mentioned and refuted and the correct information is explained. It has been argued that mentioning both correct and incorrect information (successively) is important (van den Broek & Kendeou, 2008), because it enables compare-contrast processes, which could lead to detection of the incongruence, dissatisfaction with prior knowledge and, discrepancy resolution (Chi, 2008; Chinn & Brewer, 1993; McCrudden, 2012; Posner, Strike, Hewson, & Gertzog, 1982). These processes have been argued to facilitate encoding of the revised knowledge in memory (van den Broek & Kendeou, 2008).

In general, refutation texts have been shown to be more effective than traditional science texts (Broughton, Sinatra, & Reynolds, 2010; Diakidoy, Kendeou, & Ioannides, 2003; Diakidoy, Mouskounti, Fella, & Ioannides, 2016; Diakidoy, Mouskounti, & Ioannides, 2011; Kendeou & van den Broek, 2007). However, science texts without refutations can also be effective in revising knowledge, for example when they have a text structure in which two contrasting positions are compared by pointing out similarities and differences (Diakidoy et

al., 2016; van den Broek & Kendeou, 2008). Which approach is best has been argued to depend on the type of knowledge that needs to be revised (Chi, 2013). For example, refutation texts are quite effective in changing knowledge that can be represented by one or a few idea units (Guzzetti, Snyder, Glass, & Gamas, 1993), whereas elaborate science texts with a compare-contrast format have been shown to be quite effective in changing more complex knowledge such as knowledge schemata (Chi, Roscoe, Slotta, Roy, & Chase, 2012).

The extent to which knowledge revision is successful after reading a text is often determined by assessing changes in pre- to post-test performance on knowledge tests, using the same or very similar items for the pre- and post-test (see for example Diakidoy et al., 2016; Kendeou, Walsh, Smith, & O'Brien, 2014). However, an important educational objective is that students apply revised knowledge in new contexts as well. For example, when biology teachers tell their students that global warming is not caused by natural influences but merely by human influences, they do not only expect their students to be able to apply this knowledge at the exams, but they also want their students to be aware of this outside the school context. This requires spontaneous application of revised information to new situations. Research regarding spontaneous application of revised knowledge as a result of reading refutation texts is limited. The few studies that have been conducted show that students are able to transfer revised knowledge to new situations when explicitly asked to do so (Kendeou, Braasch, & Bråten, 2016) or when asked to think aloud (McCrudden & Kendeou, 2014). But whether students apply revised knowledge spontaneously during natural reading situations has not been examined.

Aims

The general aim of this dissertation is to gain insight into the process of learning from (multiple) texts. The dissertation consists of a literature review and reports on several empirical studies. The specific aims of each chapter are to:

1. Review available literature on learning from texts and synthesize findings from the field of reading comprehension and memory (Chapter 2).
2. Create and evaluate a paradigm for studying integration processes across texts in adult readers (Chapter 3).
3. Determine whether children are able to integrate information across texts during reading and whether these processes are reflected in the knowledge representation of the texts (Chapter 4).
4. Investigate whether refutation texts are effective in achieving transfer of revised misconceptions in adult readers (Chapter 5).

Approach

All empirical studies in this dissertation followed an experimental design. Each study included behavioral measures of the reading *process* and of the resulting knowledge *representation*. With regard to the process, reading times were measured because reading times are assumed to be reflective of underlying cognitive processes (Rayner, 1977). For example, delayed reading times can reflect a failure to integrate contradictive information, due to a mismatch between currently processed information and prior text information ("The rulver is brown. […] It is difficult to see the rulver in the white snow") or background knowledge ("Cookies are sour."). Furthermore, reading times do not require a covert response of the reader, allowing students to read the texts in a relatively natural, unobtrusive way.

Contradictions can be used to determine whether information from previous experiences (i.e. prior parts of the text or background knowledge) is activated during reading and contradictions may be informative about integration processes. Several studies in this dissertation use the logic of the contradiction paradigm. In the contradiction paradigm the processing time of the same information is compared in two conditions: A condition in which the information is preceded by consistent information and a condition in which the information is preceded by inconsistent information (e.g. Albrecht & O'Brien, 1993). Any difference in reading time can only be attributed to differences in the preceding information, and must therefore reflect the activation of prior text information. The direction of the effect may be informative of integrative processes. For example, a delay in reading times may reflect difficulty integrating information. In Chapter 3 and 4 the contradiction paradigm was adapted to study the activation of information from previous texts when reading multiple texts about the same topic.

The same logic can be applied in studies investigating prior knowledge activation in the context of knowledge revision. There are two ways in which the activation of prior knowledge can be studied: 1) the processing time of the correct information is compared for students with inaccurate knowledge and accurate knowledge (e.g. Kendeou & van den Broek, 2007; Kendeou et al., 2014; van den Broek & Kendeou, 2008), or 2) the processing times of the correct information is compared for students that are assumed to have revised their inaccurate prior knowledge with those that are not assumed to have revised their inaccurate prior knowledge (e.g. Kendeou & van den Broek, 2007; Kendeou et al., 2014; van den Broek & Kendeou, 2008). Again, the compared information is usually the same in both conditions, therefore, reading time differences must reflect differences in prior knowledge activation. In Chapter 5 the second approach was used: Activation of prior knowledge was investigated

for students with common misconceptions who read refutation texts (which are argued to lead to knowledge revision) and non-refutation texts (which are argued not to lead to knowledge revision).

With regard to the knowledge representation, free recall and questions were used (that is, free recall in Chapter 3 and 4 and questions in Chapter 3, 4 and 5). In free recall students are asked to report everything they can remember about one or multiple texts. Free recall can be useful to gain insight into the text representation. The influence of the experimenter in this case is minimal; the students report what they remembered from the text without interference of the experimenter. Recall reports can be used to analyze a variety of aspects of the text representation: Amount of encoded information, specific content information, relations within and across texts, etc. In addition, specific questions were used, first because we predicted that some students would not recall any text information in the free recall sessions and needed more cues, and second because responses to more specific questions can be informative about retrieval of specific information of interest.

The samples consisted of undergraduate university students (Chapter 3 and 5) and children from 4th and 6th grade (Chapter 4). In one study (Chapter 4) several measures of individual differences were taken into account: A sentence span task to measure working memory (Daneman & Carpenter, 1980; Swanson, Cochran, & Ewers, 1989) and a national standardized reading comprehension test (Cito, 2013a, 2013b) to measure reading comprehension ability. The studies involving university students took place in laboratory settings at the university, whereas the study involving children took place at their schools in a separate room. Each participant was tested individually.

Chapter Overview

The remainder of this thesis consists of four chapters and a discussion.

The second chapter provides an overview of models that explain the process of learning from texts and empirical findings that have contributed to our knowledge about learning from texts. The chapter provides a definition of learning and describes how the act of comprehending is related to the act of learning. It explains how several factors may influence learning from texts, such as individual differences, text factors, development, learning mechanisms, and number of texts.

The third chapter focuses on one subskill of learning from texts: Making connections across multiple texts. An empirical study was conducted to evaluate a new research paradigm (i.e. the multiple-text integration paradigm) that uses the same logic as the contradiction paradigm (Albrecht & O'Brien, 1993). The multiple-text integration paradigm was used to study activation of prior text information in the context of multiple texts. In addition, recall reports were analyzed to inspect the knowledge representation that was constructed from the texts.

In the fourth chapter the experimental materials that were used previously (see Chapter 3) were adapted to make them suitable for children. Because integrations skills were expected to undergo major developments in childhood (as described in Chapter 2), children from different grades were included (Grade 4 and 6). Again, reading times and recall reports were used to gain insight into learning from texts. In addition, measures of reading comprehension ability and working memory were taken into account to determine whether these characteristics influence learning from texts.

The fifth chapter discusses the potential usefulness of refutation texts to enhance application of revised knowledge in new situations. An empirical study was conducted to determine whether readers with incorrect knowledge revise their knowledge after reading a refutation text and if so, whether they spontaneously apply this knowledge to new situations, in this case, when reading a new text. Reading times and responses to application questions were used as indications of the knowledge revision process.