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Concrete Elaboration during Knowledge Acquisition

Herman Jonker

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Concrete Elaboration during Knowledge Acquisition

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ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. L.M. Bouter,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de faculteit der Psychologie en Pedagogiek
op donderdag 14 februari 2008 om 15.45 uur
in de aula van de universiteit,
De Boelelaan 1105

door

Herman Gerard Jonker

geboren te Leiden

promotor	prof.dr. J.J. Beishuizen
copromotor	dr. M.V.J. Veenman

Voorwoord

Aan veel mensen ben ik dank verschuldigd. Allereerst bedank ik mijn promotor, prof.dr. Jos Beishuizen. Jos, met enige regelmaat vertelde je me dat ik je eerste promovendus ben. Je hebt al een reeks lofredes op je naam staan, maar ik ben dan toch de eerste voor wie je de laudatio als hoogleraar zult uitspreken. Vanzelfsprekend zal de lijst met promovendi gestaag groeien de komende jaren en ik beschouw het als een eer dat ik op die lijst sta. Van jou heb ik het belang van een wetenschappelijke houding geleerd en hoe ideeën en praxis in elkaar kunnen grijpen. Daarop zal ik in mijn verdere loopbaan nog vaak teruggrijpen.
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Zonder leerlingen geen (experimenteel) onderzoek en geen proefschrift. Zij hebben moeten zweten om onder allerlei experimentele condities teksten te bestuderen. Ik bedank hen ook als ik de namen noem van hun bereidwillige rector, coördinator of docent. In Amsterdam zijn het op het St.- Ignatiusgymnasium Hans Buijze en op het Sint-Nicolaaslyceum Joris Ruijter en in Leiden op het Visser 't Hooft Lyceum betreft het Erik Heijnis.

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Amsterdam, december 2007

Chapter 1 Introduction

Ask a secondary school student why she likes her history teacher. She may answer, “Because he is a good story-teller”. History teachers use stories to convey the meaning of historical concepts. By induction, the student abstracts the meaning of concepts from stories describing historical events. But what about the teacher who starts a lesson on imperialism by providing a definition, such as: "Practice by which powerful nations or peoples seek to extend and maintain control or influence over weaker nations or peoples" (Microsoft Encarta '95, 1994), and continues by asking students to think of examples of European expansion after 1870. By deduction, the student applies the definition to a case and decides whether the case is an example of imperialism. Both approaches seem worthwhile. However, the superiority of one approach over the other has often been proclaimed. Constructivists advocate the inductive approach, by stating that learning should take place in rich contexts, in constructive, generative, and authentic learning tasks, which require group discussions (Cognition and Technology at Vanderbilt University, 1992). The deductive approach has also had many supporters. Nisbett (1993) stated that abstract rules exist, and can be taught in a top-down, abstract manner. Ohlsson (1993) concluded: "Thinking that goes beyond immediate experience is regulated by knowledge structures called abstract schemas" (p. 51). This statement implies a well-known paradox, Meno's Paradox, reformulated as the Learning Paradox by Bereiter (1985): In order to acquire knowledge one ought to have prior knowledge of equal complexity as the knowledge to be learned.

Induction, deduction and abduction

In an attempt to tackle the learning paradox, Prawat (1999) comes up with four possible solutions, to conclude that neither induction, deduction, nor the postmodern approach (see e.g. Rorty, 1979) will solve the paradox. It is only through metaphoric, abductive processes that we can explain how we are able to learn things of higher complexity than our minds possess at the moment of learning. However, the reader will not find the concept of abduction or abductive thinking in the remainder of this book. We regard the concepts of induction in conjunction with deduction as particularly helpful in explaining text comprehension processes. That is not to say that discussing knowledge acquisition, when *not* limited to text comprehension, might serve, or even warrant abduction as an explanatory concept. The experimental nature of this dissertation combined with the fact that we *do* limit knowledge acquisition to text comprehension, means that this issue is not applicable to this thesis.

Concrete elaboration and studying and expository text

In this study, the problem of the Learning Paradox was addressed by adding a new dimension: The student's learning style. According to Sternberg and Grigorenko (1997) learning styles should be conceived of as a bridge between personality and cognitive factors. Learning styles are best thought of as general, relatively stable, preferences. Hence, a learning style is not an ability, it is a habit. According to Vermunt and Van Rijswijk (1988), a learning style "refers to a coherent whole of activities, study orientations and conceptions of learning [...] that is characteristic for a certain student at a certain moment in time" (pp. 654-655). Vermunt (1992) understands the concept of learning style as consisting of four aspects: (1) Processing strategies, (2) regulation strategies, (3) mental models of learning, and (4) learning orientations. From these aspects Vermunt subsequently arrives at four different learning styles: Undirected learning style, reproduction directed learning style, application directed learning style, and meaning directed learning style.

Students differ in the extent to which they spontaneously generate examples when they encounter concepts and principles presented in a study text. Vermunt (1992) called this habit "concrete elaboration". The Concrete Elaboration scale of Vermunt's (1992) Inventory of Learning Styles has been found to be reasonably reliable (Prins, Busato, Hamaker, & Visser, 1996; Prins, Busato, Elshout, & Hamaker, 1998). In this study, evidence was sought for an aptitude-treatment interaction (ATI) showing that students with a strong tendency to concrete elaboration prefer a deductive learning task, whereas students with a weak tendency to concrete elaboration benefit from an inductive learning task. The existence of this aptitude-treatment interaction was supposed to account for contradictory findings about the role of examples in expository texts. In some studies, examples were reported to distract the reader's attention from what the text really was about (Harp & Mayer, 1997; Wade, Schraw, Buxton, & Hayes, 1993). However, examples were also shown to help the learner to understand abstract concepts (Sadoski, Goetz, & Fritz, 1993; Beck, McKeown, & Worthy, 1995).

This thesis focused on the student's learning style in relation to the deductive versus inductive learning task. In two previous experiments, evidence was found for an aptitude-treatment interaction between Vermunt's (1992) Concrete Elaboration learning style and the effects of a deductive versus inductive learning task.

Beishuizen, Stoutjesdijk, Spuijbroek, Bouwmeester, and Van der Geest (2002) replicated Fong et al. (1986), and gave students two versions (a rule variant and an examples variant) of an expository text on the law of large numbers. They found that a high level of Concrete Elaboration enhanced the score on the post test for the rule training group, but lowered the results for the examples training group. The students who scored low on the Concrete Elaboration scale displayed opposite results.

Beishuizen, Asscher, Prinsen, and Elshout-Mohr (2003) presented a study text from a first-year course on Educational Psychology to 98 first-year students. The text contained five different types of sections: (1) Sections with a main idea and two examples, (2) with a main idea and five examples, (3) with a main idea and one relevant and one irrelevant example, (4) with two examples and no main idea, and (5) sections with just a main idea. Beishuizen et al. (2003) found that students who scored high on the Concrete Elaboration scale scored better than students who scored low on the Concrete Elaboration scale on questions about sections without examples (type 3) or with an irrelevant example (type 5). Whereas students who scored low on Concrete Elaboration outperformed the high 'concretisers' on questions about sections with a main idea and two or five examples (type 1 and 2). As a result of their study, Beishuizen et al. (2003) suggested two interpretations of the Concrete Elaboration learning style: (1) The adaptation versus accumulation explanation, or (2) the deductive versus inductive learning explanation.

According to the adaptation versus accumulation explanation, high Concrete Elaboration students take their own knowledge as point of departure: On encountering a concept in a study text, they adapt existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many examples. Low Concrete Elaboration students do not activate existing knowledge to the same extent and try to accumulate as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

The alternative deductive versus inductive learning explanation is inspired by Chi and VanLehn (1991) who showed that students, studying physics examples, generated two kinds of explanations: The first type of explanation indicated a deductive approach: Instantiating a general principle with information in the example statement. The second type indicated an inductive approach: Generalization and extension of the example statement. To put it differently, readers may reason either from general principles to examples by taking the principle as point of departure (the deductive approach), or from examples to general principles (the inductive approach) by abstracting general principles from examples. Students high on Concrete Elaboration adopt the deductive approach whereas students low on Concrete Elaboration prefer the inductive approach.

Overview of the dissertation

The research reported in this dissertation built upon the two aptitude-treatment interaction studies reported above, by disentangling the interaction between learning style and learning task, in particular the two explanations of data from Beishuizen et al. (2003) . In Chapter 2, the relationship between Concrete Elaboration and actual reading was explored by asking students to think aloud while they were reading an expository text. The aim of this study was to establish a relationship between individual differences in learning style, measured by a standard inventory of learning styles like the ILS (Vermunt & Van Rijswijk, 1988; Vermunt, 1992), and the process of studying an expository text. In Chapter 3, two characteristics of the learning task were manipulated: Presentation format (paper versus screen) and study time (fixed time versus flexible time). Presentation format was changed in Chapter 4 by providing the study text in hypertext format, with buttons which have to be clicked to enter a paragraph. Apart from using facilities for closely monitoring the student's more explicit reading behaviour, this created an opportunity for broadening the project's scope. Although an aptitude treatment interaction between the cognitive style field dependence/independence and search experience on the Web has been found (Palmquist & Kim, 2000), the Concrete Elaboration learning style has as yet not been related to using hypertext or the Web as a source of information (Ford, 2000). In Chapter 5 the study goal was changed. Instead of preparing for a comprehension test, students had to study an expository text in order to prepare for conducting experiments in a simulation environment. In this context, the study goal entailed building an internal representation of the relationships between different variables, which could subsequently be tested by conducting experiments. By making the study goal more explicit and specific, more clear-cut differences were expected between students with high and low scores on Concrete Elaboration. Moreover, using an expository text to conduct experiments in a simulation environment enabled us to relate the high versus low Concrete Elaboration distinction to Klahr and Dunbar’s (1988) Scientific Discovery as Dual Search (SDDS) theory. In SDDS theory a distinction has been proposed between so-called "theorists" and "experimenters". Theorists and experimenters approach an inductive learning task by either focusing on the "hypothesis space", the set of all possible hypotheses explaining a rule to be discovered in the simulation environment, or focusing on the "experiment space", the set of all possible experiments to be conducted in the simulation environment. By adding an expository text with principles and examples to a simulation environment, it became possible to explore relationships between Concrete Elaboration in the context of studying an expository text and the theorists/experimenters distinction relevant for inductive learning by conducting experiments. Previously, a simulation environment for inductive learning, FILE (Wilhelm & Beishuizen, 2003) has been developed and extensively tested with primary school students, secondary school students, and adults. The environment used in Chapter 5 was adapted from FILE. Chapter 6 discusses the main findings of the experiments described in Chapters 2 to 5. From these results a hypothetical model was postulated. Finally, scientific and educational implications were suggested.

References

Beck, I.L., McKeown, M.G., & Worthy, J. (1995). Giving a text voice can improve students' understanding. *Reading Research Quarterly, 30*, 2, 220-238.

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology, 73*(3), 291-316.

Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology, 72,* 279-297.

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*(2), 201 - 226.

CTGV (Cognition and Technology Group at Vanderbilt University) (1992). Technology and the design of generative learning environments. In Th. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction* (pp. 77-91). Hillsdale, NJ: Erlbaum.

Chi, M. T. H., & VanLehn, K. A. (1991). The content of physics self-explanations. *Journal of the Learning Sciences, 1*(1), 69-105.

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The effects of statistical training about everyday problems. *Cognitive Psychology, 18*, 253-292.

Ford, N. (2000). Cognitive styles and virtual environments. *Journal of the American Society for Information Science, 51*(6), 543-557.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Klahr, D., & Dunbar, K. (1988). Dual-space search during scientific reasoning. *Cognitive Science, 12*(1), 1-48.

Microsoft Encarta '95. (1994). Redmond, WA: Microsoft Corporation.

Nisbett, R. E. (1993). Reasoning, abstraction, and the prejudices of 20th century psychology. In R. E. Nisbett (Ed.), *Rules for Reasoning* (pp. 1-15). Hillsdale, N.J.: Erlbaum.

Ohlsson, S. A. (1993). Abstract schemas. *Educational Psychologist, 28*(1), 51-66.

Palmquist, R. A., & Kim, K. S. (2000). Cognitive style and on-line database search experience as predictors of Web search performance. *Journal of the American Society for Information Science, 51*(6), 558-566.

Prawat, R. S. (1999). Dewey, Peirce, and the learning paradox. *American Educational Research Journal, 36*(1), 47-76.

Prins, F. J., Busato, V. V., Elshout, J. J., & Hamaker, C. (1998). Een nieuwe bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen (ILS). [A new contribution to the validation of a part of the Inventory of Learning Styles]. *Pedagogische Studiën, 75*(2), 73-93.

Prins, F. J., Busato, V. V., Hamaker, C., & Visser, K. H. (1996). Een bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen [A contribution to the validation of the (meta)cognitive part of the Learning Styles Inventory]. *Pedagogische Studien, 73*(2), 108-122.
Rorty, R. (1979). *Philosophy and the Mirror of Nature*. Princeton, NJ: Princeton University Press.
Sadoski, M., Goetz, E. T., & Fritz, J. B. (1993). Impact of Concreteness on Comprehensibility, Interest, and Memory for Text - Implications for Dual Coding Theory and Text Design. *Journal of Educational Psychology, 85*(2), 291-304.
Vermunt, J. D. H. M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken* [Learning styles and controlling learning processes in higher education: a process oriented instruction in independent thinking]. Swets & Zeitlinger, Amsterdam.
Vermunt, J. D. H. M., & Van Rijswijk, F. A. W. M. (1988). Analysis and development of students' skill in self-regulated learning. *Higher Education, 17*, 647-682.
Wade, S.E., Schraw, G., Buxton, W.M., & Hayes, M.T. (1993). Seduction of the strategic reader: effects of interest on strategies and recall. *Reading Research Quarterly, 28*, 2, 93-114.

Wilhelm, P., & Beishuizen, J. J. (2003). Content effects in self-directed inductive learning. *Learning and Instruction, 13*(4), 381.

Chapter 2 Understanding an expository text – a process analysis[1]

Abstract

The aim of this study was to establish a relationship between individual differences in learning style and the process of studying expository text. Students were assessed on their level of concrete elaboration (CE, Vermunt, 1992). We categorized students' elaborations during reading and thinking aloud text studying sessions into four types: conceptual elaborations, inductive elaborations, deductive elaborations and instance elaborations. High CE students displayed a more differentiated profile of elaborations than low CE students. High CE students confirmed Vermunt's characteristic of the learning style of concrete elaboration: They gave concrete form to what they read. Low CE students, however, displayed less clear habits. The conclusion seems warranted that students are more focused on giving concrete form to what they read than on building a theoretical framework. The study favours the adaptation versus accumulation explanation to the deductive versus inductive explanation.

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[1] Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). *Understanding an expository text – a process analysis.*

Introduction

Secondary school students, within one or two years of entering university, are often unaware of how to go about extracting meaning from an expository text. The problem is multifaceted: How does one distinguish between and among "important" parts of the text? Should one focus on examples and elaborations, which may help to illustrate concepts but may cause the reader to get lost in the details? Or should one focus on the main ideas, risking a superficial representation, not related to concrete experience? The present paper focuses upon the way upper secondary school students extract the core meaning from an expository text. A group of 17 to 18 year old students was chosen because they were preparing for higher (professional or university) education. The study did not adopt a developmental (longitudinal or cross-sectional) approach. Rather, the group was deemed relevant because in this preparatory stage, instructional support to enhance text comprehension skills may be particularly effective.

The aim of this study was to establish a relationship between individual differences in learning style, measured by a standard inventory of learning styles like the Inventory of Learning Styles ILS (Vermunt & Van Rijswijk, 1988; Vermunt, 1992), and the process of studying an expository text. Vermunt (1992) included in his inventory a scale named “Concrete Elaboration”, which assesses the extent to which students display the habit of spontaneously activating episodes of personal experience when reading a study text. In line with Vermunt (1992) we assume that learning styles reflect habits of consciously choosing information processing strategies in the face of a particular cognitive task. The habitual reading strategies we studied in this research were supposed to be developed by our participants as a result of a period of approximately 11 years of study experience. The Concrete Elaboration scale has been found to be reasonably reliable (Prins, Busato, Hamaker, & Visser, 1996; Prins, Busato, Elshout, & Hamaker, 1998). Vermunt (1992) defined “concrete elaboration” (CE) as “relating course contents to concrete things that are already known, such as personal experiences, concrete visual images, events in daily reality, practical applications” (p. 650). Students with a high score on CE use the course content to generate concrete examples of everyday practice out of their personal experience.

Beishuizen, Asscher, Prinsen, & Elshout-Mohr (2003) presented a study text to first year psychology students with high and low scores on Vermunt's Concrete Elaboration Scale. The text contained chapters with many examples and few theory descriptions but also chapters with many theory descriptions and few examples. Some examples were relevant for the theory description in a particular chapter and some were irrelevant. The results on a comprehension test showed that students performed relatively low on chapters with irrelevant examples. Apparently, irrelevant examples distracted the students. Contrary to the expectations of Beishuizen et al., students with a high score on the Concrete Elaboration (CE) Scale did not perform well on chapters in which a theory description preceded some examples, whereas they earned better results on posttest questions referring to chapters in which examples were put in front of a theory description. Perhaps, these high Concrete Elaboration (CE) students have the habit of using a theory description to generate relevant examples from their own experience. When examples follow a theory description in the text, this process of activating personal experiences may interfere with paying attention to the examples in the text, leading to a lower score on the posttest. Two different explanations were postulated in Beishuizen et al. (2003). According to the adaptation versus accumulation explanation, high CE students take their own knowledge as point of departure: On encountering a concept in a study text, they adapt existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge in order to arrive at a coherent representation. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many examples. Low CE students do not activate existing knowledge to the same extent and try to pay attention to as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

The alternative deductive versus inductive learning explanation is inspired by Chi and VanLehn (1991) who showed that students studying physics examples, generated two kinds of explanations. The first type of explanation indicated a deductive approach: instantiating a general principle with information in the example statement. The second type indicated an inductive approach: generalization and extension of the example statement. To put it differently, readers may reason either from general principles to examples by taking the principle as point of departure (the deductive approach), or from examples to general principles (the inductive approach) by abstracting general principles from examples. High CE students adopt the deductive approach whereas low CE students prefer the inductive approach. Today a synthesis of these two approaches is widely accepted (see e.g. Van den Broek, Rapp & Kendeou, 2005; Rapp & Van den Broek, 2005). Van den Broek, Virtue, Everson, Tzeng, & Sung, (2002) found evidence for an interaction between a passive, memory-based process and active, constructionist processes. Or, to put it in other words, there is a trade-off between the pursuit for coherence and the attentional limitations of the human cognitive processing system during reading for comprehension.

The conclusions of Beishuizen et al. (2003), however, were based solely on posttest scores and not on the examination of the reading process itself. Therefore, we decided to apply a reading- and thinking-aloud method in order to study the reading and understanding process concurrently. Trabasso and Suh (1997, pp. 543) conclude that "…thinking aloud provides substantial support for the claim that this form of concurrent verbal protocol is psychologically valid and pedagogically informative …". The reading- and thinking- aloud method is being used frequently in cognitive research for collecting verbal data during task performance (Ericsson &

Simon, 1980, 1993). Protocol analysis has been used to reveal processing of diverse tasks, including physics problem solving (Simon & Simon, 1988; Veenman & Elshout, 1995), student cognitions during instruction (Peterson, Swing, Braverman, & Buss, 1982), and, what we are mostly interested in, reading comprehension (Olshavsky, 1976, Pressley and Afflerbach, 1995; Veenman & Beishuizen, 2004). Hyona & Nurminen (2006) showed that adult readers were well aware of their general reading speed and reasonably aware of their 'lookback' and 'rereading' behaviour. It is this kind of awareness that we are looking for but here with respect to the CE learning style. Of course, readers may differ in amount of verbosity when asked to read and think aloud. However, there are no a priori reasons to relate this level of verbosity to either the high or low CE learning style. Therefore, to accommodate for varying levels of verbosity in the reading and thinking aloud protocols, we analysed and compared proportions instead of absolute numbers of various types of elaborative comments.

This study investigated whether the learning style Concrete Elaboration, as measured by Vermunt's ILS, determines the number and distribution of comments during the reading- and thinking-aloud task, reflecting the process of studying expository texts. We prepared an expository text with two types of paragraphs: Theory paragraphs (many concepts, few examples) and example paragraphs (many example, few concepts). We developed a rating scale for interpreting the reading- and thinking-aloud protocols. First, a distinction was made between affective, regulative and cognitive utterances (Vermunt, 1992). Next, within the category of cognitive utterances, elaborations were identified as statements about the content of text entailing an element of novelty, an assertion that is not part of the original study text. These elaborations are categorized as general theoretical comments and summative comments, both at an abstract level, and example comments at a concrete level.

By relating the prevalence of abstract and concrete comments to the learning style of the participant, as measured by the Concrete Elaboration (CE) scale of the Inventory of Learning Styles (Vermunt & Van Rijswijk, 1988), we were able to investigate whether high CE participants produce more concrete comments during theory paragraphs (*deductive elaborations*) and low CE participants produce more abstract comments during example paragraphs (*inductive elaborations*). However, we also took into account abstract elaborations during theory paragraphs and concrete elaborations during example paragraphs, thus arriving at four types of elaborations. These four types of elaborations can be related to literature on inference generation (Narvaez, van den Broek, and Ruiz, 1999), in which a distinction is proposed between bridging, predictive, or elaborative inferences. Our four types of elaborations all belong to the category of elaborative inferences.

1. <u>Abstract Comments in Theory Paragraphs</u>. Students relate their existing conceptual network to new theory descriptions. This category is referred to as *conceptual elaborations*. Students seem to directly connect a concept-in-the-text with a

concept-in-the-mind. They do not report any intermediary role of concrete examples or experiences stored in their episodic memory.

2. Abstract Comments in Example Paragraphs. Students elaborate at a conceptual level, with general or summative comments, on examples in the text. Students create new concepts or activate existing concepts on the basis of examples in the text. We designate this category to be *inductive elaborations*. One might envision that this kind of elaboration signifies the process of understanding.

3. Concrete Comments in Theory Paragraphs. Concrete elaborations in paragraphs with theory descriptions reveal deductive processes: Students apply an abstract theory description by activating an existing example or episode of experience. This category is denominated *deductive elaborations*.

4. Concrete Comments in Example Paragraphs. These elaborations extend the representation of the text at a concrete level by adding examples or concrete episodes in the mind to the examples in the text. This kind of elaboration seems, at first sight, quite redundant. However, one might interpret this elaborative process as a process of understanding by replacing the examples in the text with examples originating from the student's own experience. We classify this category as *instance elaborations*, emphasizing that instances of concepts in the text are related to instances of concepts in the student's mind.

We expected students with a high score on Concrete Elaboration to produce many deductive elaborations and students with a low score on Concrete Elaboration to produce many inductive elaborations but did not have specific hypotheses as to the relationship between Concrete Elaboration and the occurrence of conceptual or instance elaborations.

Method

Participants

Seventy 11th grade students, 35 male and 35 female, participated in this study. The mean age of the students was 16.53 years (*SD* = .63). The students came from two different secondary schools in Amsterdam (30 students) and Leiden (40 students), with which the research institute maintains regular contact. In both schools, the ILS questionnaire was administered to the whole 11th grade cohort, after which the students were invited to participate in the study. The sample was split across the median to separate the high from the low CE students (ILS score < median). Students participated on a voluntary basis and received a small remuneration after having completed the experimental tasks.

Materials

Learning Styles Inventory

The Concrete Elaboration (CE) Scale of Vermunt's (1992, 1998) Inventory of Learning Styles (ILS) was used to measure the students' habit of giving concrete form to what they read. The five-point scale consisted of five relevant statements and five filler statements (see appendix). On the five items of the five-point scale, students scored on average 13.24 (*SD* = 3.38). The reliability coefficient of this short inventory was satisfactory (Cronbach's alpha = .68). Students with a score below the median (13) were allocated to the low CE subgroup. All remaining students were allocated to the high CE subgroup.

Study texts

Two study texts were used in this experiment. The *perception and attention* text (T1) was constructed from existing materials. First, a popular science documentary on *perception and attention* was selected from a publicly broadcasted science show. Based on a transcript of the documentary and relevant chapters of Gleitman's (1991) introductory psychology textbook, a study text was constructed. The text consisted of 24 theory paragraphs, 23 example paragraphs, and 6 introductory paragraphs.

The *evolution* text (T2) was derived from a popular science book (Haring, 2002). The general principles of *evolution* theory were applied to realms other than biology. This text on *evolution* consisted of 22 theory paragraphs and 17 example paragraphs.

Both texts were compared on various text difficulty indicators. A significant difference in average sentence length was obtained (t (290) = 2.97, p < .01) as sentences in the *perception and attention* text were composed of more words (M = 22.99 words, SD = 10.88) than sentences in the *evolution* text (M = 19.48 words, SD = 9.28). Van Hout-Wolters (1986) however, argued that readability indicators should be used in conjunction with a judgmental approach of assessing text difficulty (see also Veenman & Beishuizen, 2004). Therefore, eight independent judges (Cronbach’s alpha = .94) scored both texts on Likert scales with regard to indicators of text difficulty (adapted from Linderholm et al. 2000): (1) The prerequisite knowledge required for reading the text (t (7) = 5.16, p < .01) (2) the complexity of concepts (t (7) = 8.81), p < .01); (3) the complexity of the relations between concepts (t (7) = 5.00), p < .01); (4) the (lack of) coherence in the text (t (7) = -1.05, n.s.); (5) the (lack of) explicitness of goals and themes (t (7) = -1.00, n.s.); and (6) the overall complexity of the text (t (7) = 7.33, p < .01). These data confirm that text 1 was a more difficult text than text 2 with respect to text length, sentence length, number and complexity of concepts, prerequisite knowledge and overall complexity of the text. Table 1 shows the means and standard deviations for both texts.

Table 1. Readability Assessments of the Two Experimental Texts

	Perception and Attention Text		Evolution Text	
	M	*sd*	*M*	*sd*
1. The prerequisite knowledge required for reading the text.	4.25	1.75	1.88	.64
2. The complexity of concepts.	5.63	1.19	2.38	.92
3. The complexity of the relations between concepts.	5.25	1.39	2.75	.46
4. The coherence in the text	4.63	1.69	5.25	1.49
5. The explicitness of goals and themes.	4.63	1.69	5.50	.93
6. The overall complexity of the text.	5.50	1.31	2.13	.64

<u>Rating scale for reading- and thinking-aloud protocols.</u>

In order to categorize the verbal utterances in the reading and thinking aloud protocols, a rating scale was developed, based on Vermunt's (1992) distinction between cognitive, affective and regulative processes. Cognitive comments were further subdivided into elaborative comments (statements about the content of text entailing an element of novelty, an assertion that was not part of the original study text) and other cognitive comments. Within the category of elaborative comments four subcategories were distinguished: Conceptual elaborations (abstract comments in theory paragraphs), inductive elaborations (abstract comments in example paragraphs), deductive elaborations (concrete comments in theory paragraphs), and instance elaborations (concrete comments in example paragraphs). Some examples of various elaborative comments are given in Table 2.

Out of the 70 *perception and attention* protocols, 30 were categorized independently by two judges. The resulting Cohen's Kappa (Van Someren, Barnard, & Sandberg, 1994) was .89. The remaining protocols, including the *evolution* protocols, were scored by one judge.

Table 2. Examples of Conceptual, Inductive, Deductive, and Instantial Elaborative Comments.

Conceptual Elaborations
Because of redundant information, I would say [sitting] at a computer.
One is deceived by what one sees, normally one's perception helps but illusions deceive our system.
Now I think of movies in which you don't pay attention to small things, but when you see the movie for the second time you do see [the small things] and it becomes a different movie that you are watching.
Now I think back of what we learned from physics, that the color green only reflects green because white encompasses all colors.
So what people perceive can be subdivided in basic issues.
Yes that is true, when you look at an unfamiliar object you are not actually going to think what are the main features, what the contours, so you don't really think about that.
Well the conclusion must be that there are innate categories, squares and triangles, with experience these are being extended.
Inductive Elaborations
When he walks away, he gets smaller in reality but not in your thoughts, on your retina yes, but not in your brains.
What you hear, changes when you know more of it.
Yes, now I am thinking of a New York cab driver who has to be alert all the time for traffic from the left and from the right, because it is so crowded over there.
Now I am thinking of the times when I started to learn Greek because my parents are Greek and I was born there, and in the beginning I too was completely unaware of where a word stopped, in the beginning you think it is like Chinese and it is like other foreign languages, so to speak.
Well I'm trying to remember what an ellipse actually is, say not a perfect round figure, that it is actually quite logical to assume subconsciously that these objects are in fact round because you know them from different positions where they hang straight.
That's true, once you know something, you cannot pretend not to know it.
Deductive Elaborations
A sort of Plato idea with the horse and with the depiction of the horse.
Like with visual illusions.
Sounds like developing a simple computer program for recognition of objects.
I have to think of a program, in which it was said that 1%, wait 99% of everything you see is phantasy, it is all being supplemented in your brain and your experience
Instance Elaborations
Yes now I am thinking of a New York cab driver who has to be alert all the time for traffic from the left and from the right, because it is so crowded over there.
Now I am thinkink of the times when I first started to leran Greek because my parents are Greek and I was born there, and in the beginning I too was completely unaware of where a word stopped, in the beginning you think it Chinese and it is like other foreign languages, so to speak.

Procedure

All students had to read aloud the *perception and attention* study text and think aloud during the session. The instructions given to them were as follows: to speak up freely about anything that comes to mind at any point in the text, to take it slowly, and to strive for understanding in such way as to be able to answer the questions afterwards. Therefore, we decided not to include prompts. However, when a student remained silent for more than five seconds at a stretch, the experimenter encouraged thinking and reading aloud by stating: "Keep talking!"

Twenty-six students were additionally presented with a second text, the *evolution* text, following exactly the same procedure as the *perception and attention* text. For practical reasons, it was impossible to present the *evolution* text to the remaining 44 participants.

Results

In order to test the hypothesis that high CE students produced more concrete elaborations during theory paragraphs than during example paragraphs, while low CE students generated more abstract elaborations during example paragraphs than during theory paragraphs, we ran various repeated measures analyses. Because the distribution of affective, cognitive and regulative comments was unequal for both study texts, we ran separate analyses for the *perception and attention* text and for the *evolution* text.

The distribution of elaborative comments during reading- and thinking-aloud the *perception and attention* text was analyzed with a repeated measures analysis with Type of Paragraph (theory versus example) and Type of Comment (abstract versus concrete) as within subjects variables, Learning Style as between subjects variable, and Proportion of Comments as dependent variable. Table 3 displays the data.

Table 3. Proportions of Abstract and Concrete Comments during Reading and Thinking Aloud the Perception and Attention Text.

	Concrete Elaboration			
	Low		High	
	n = 35		*n* = 34	
	M	*sd*	*M*	*sd*
Conceptual Elaborations: Abstract Comments in Theory Paragraphs	0.28	0.21	0.26	0.21
Inductive Elaborations: Abstract Comments in Example Paragraphs	0.05	0.11	0.08	0.28
Deductive Elaborations: Concrete Comments in Theory Paragraphs	0.32	0.25	0.47	0.09
Instance Elaborations: Concrete Comments in Example Paragraphs	0.23	0.29	0.14	0.21

Theory paragraphs elicited a higher proportion of comments ($M = .33$, $SD = .16$) than example paragraphs ($M = .12$, $SD = .13$; $F(1, 67) = 44.45$, $p < .01$). Participants produced a higher proportion of concrete comments ($M = .29$, $SD = .14$) than abstract comments ($M = .17$, $SD = .12$; $F(1, 67) = 24.10$, $p < .01$). The interaction between the within subjects variables and Learning Style turned out significant ($F(1, 67) = 7.06$, $p < .01$). Figure 1 displays the interaction. High CE students produced a high proportion of deductive comments (concrete comments in theory paragraphs) and a low proportion of inductive comments (abstract comments in example paragraphs), which was expected. However, the low CE students did not behave as expected, as they produced a lower proportion of comments in example paragraphs than in theory paragraphs. Moreover, they made a lot of deductive comments (concrete comments in theory paragraphs). Again, this was not expected. So, there was a clear indication of deductive learning in theory paragraphs, in particular by high CE students.

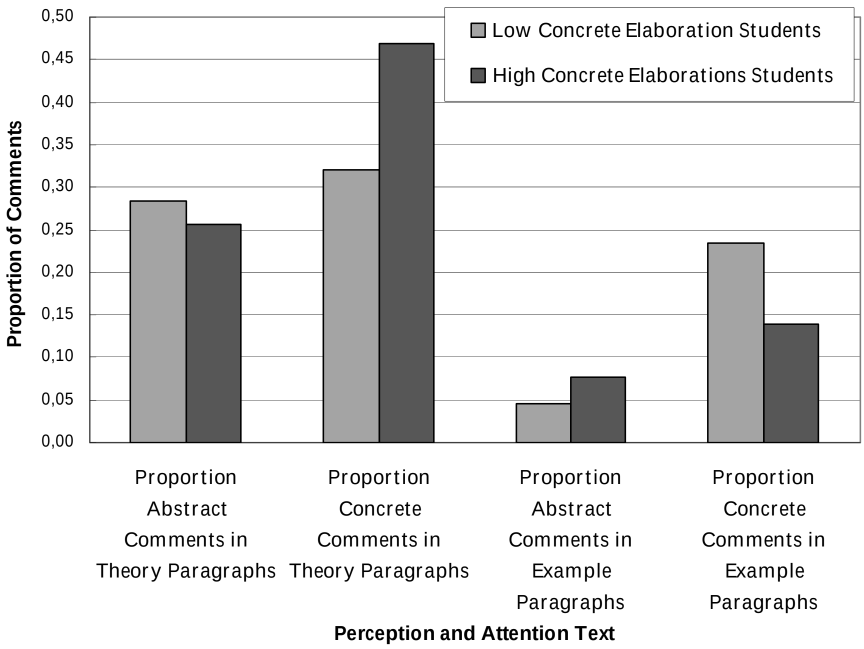

Figure 1. *Interaction between Concrete Elaboration Style (High versus Low) and the Two Within Subject Variables Representing the Distribution of Elaborative Comments (Type of Paragraph and Type of Comment) during Reading and Thinking Aloud the Perception and Attention Text.*

The distribution of the proportion of elaborative comments during reading- and thinking-aloud the *evolution* text was analyzed with a repeated measures analysis with Type of Paragraph (theory versus example) and Type of Comment (abstract versus concrete) as within subjects variables, Learning Style as between subjects variable, and Proportion of Comments as dependent variable. Theory paragraphs elicited a higher proportion of comments (M = .24, SD = .20) than example paragraphs (M = .11, SD = .15; F (1, 67) = 5.24, p < .05). Table 4 displays the data.

Table 4. Proportions of Abstract and Concrete Comments during Reading and Thinking Aloud the Evolution Text.

	Concrete Elaboration			
	Low *n* = 11		High *n* = 13	
	M	*sd*	*M*	*sd*
Conceptual Elaborations: Abstract Comments in Theory Paragraphs	0.26	0.33	0.41	0.39
Inductive Elaborations: Abstract Comments in Example Paragraphs	0.08	0.12	0.02	0.06
Deductive Elaborations: Concrete Comments in Theory Paragraphs	0.07	0.11	0.21	0.31
Instance Elaborations: Concrete Comments in Example Paragraphs	0.23	0.31	0.13	0.19

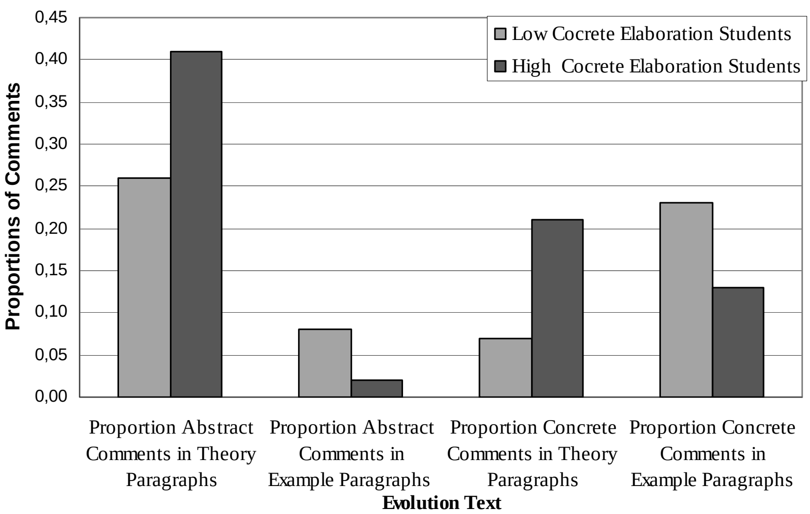

Figure 2. Interaction between Concrete Elaboration Style (High versus Low) and the Two Within Subject Variables Representing the Distribution of Elaborative Comments (Type of Paragraph and Type of Comment) during Reading and Thinking Aloud the Evolution Text.

The main effect of Type of Paragraph was influenced by Concrete Elaboration Style. As Figure 2 shows, high CE students made a higher proportion of comments in theory paragraphs and low CE students made a higher proportion of comments in example paragraphs. Although this interaction between Type of Paragraph and Learning Style was not significant, a trend was found.

There was no main effect of Type of Comments (F (1, 22) < 1). Figure 2, however, shows that theory paragraphs elicited a higher proportion of conceptual comments (abstract comments in theory paragraphs), whereas example paragraphs elicited a higher proportion of instance comments (concrete comments in example paragraphs). This interaction between Type of Paragraph and Type of Comment was significant (F (1, 22) = 9.76, p < .01). Although the hypotheses were focused on the differences between high and low CE students, an implicit assumption was that theory paragraphs would give rise to concrete comments (deduction), and example paragraphs would give rise to abstract comments (induction). Again, the latter type of learning did not show up in the reading and thinking aloud data.

Discussion

A comparison of self-report data and reading and thinking aloud data with respect of Vermunt's (1992, 1998) Concrete Elaboration learning style revealed some similarities but also some differences. Students produce a higher proportion of concrete elaborations (deductive elaborations and instance elaborations) than theory elaborations. Inductive elaborations are very rare. Taking their elaborative comments into account, the conclusion seems warranted that students, in particular students with a high score on Vermunt's (1992, 1998) Concrete Elaboration Scale, are more focused on giving concrete form to what they read than on constructing a theoretical framework.

Comparing the two texts, the difficult text and the easy text, a difference showed up with respect to the type of paragraph in which students prefer to elaborate. Students produced a lot of deductive elaborations during the difficult text and many conceptual and instance elaborations during the easy text. This shift from elaborating in difficult theory paragraphs to elaborating in easy theory and example paragraphs seems counterintuitive. One can imagine that in difficult expository texts the example paragraphs offer a more viable route to understanding than the theory paragraphs. However, inductive knowledge construction was very rare in this study with these texts and these students. One might envisage that the lack of inductive elaborations was an artifact of the double task of simultaneously reading and thinking aloud. However, if that were the case, we would have expected a higher proportion of inductive elaborations in the relatively easy *evolution* text as compared with the *perception and attention* text. In accordance with Vermunt, concrete elaboration, from concept-in-the-text to example-in-the-mind, was applied as the favourable strategy for representing the meaning of the text, particularly by high CE students. However, in the easy text the direct route from concept-in-the-text to concept-in-the-mind was often chosen, particularly by high CE students. Because the students reported that the text on *evolution* was too self- explanatory to elaborate upon, many protocols did not contain any elaborative comments. Self-explanatory seems to be the right word, because students did not need to do the bridging and elaborating inferences. It can be considered further evidence for the main point McNamara et al. (1996) state when they put up the question: Are good texts always better?

Comparing the two types of students, it is clear that high CE students displayed a more differentiated profile of elaborations than low CE students. High CE students confirmed Vermunt's characteristic of the learning style of concrete elaboration: They gave concrete form to what they read. Low CE students, however, displayed less clear habits. In that respect, they also confirmed Vermunt's conceptualization. They simply did not adopt the learning style of concrete elaboration. But did they follow an alternative strategy? The inductive approach was not chosen, and our hypothesis was not confirmed. In both texts, low CE students produced more instance elaborations, which confirms at least partly our expectation that low CE students are more active in example paragraphs than in theory paragraphs.

The data supports the findings of Beishuizen et al. (2003), that high CE students activate their own examples and concrete experiences when studying theoretical explanations. By asking students to read and think aloud during the process of studying an expository text we observed that high CE students were indeed active in theory paragraphs and raised their own concrete examples.

It is clear that this study provides evidence in favour of the adaptation versus accumulation explanation. High CE students used their own knowledge as point of departure, whereas low CE students did not display any preference to particular chapter types as far as their style of processing is concerned. Neither did they show clear signs of inductive learning, which was predicted by the deductive versus inductive learning explanation.

References

Anderson, J. R., Fincham, J. M., & Douglass, S. (1997). The role of examples and rules in the acquisition of a cognitive skill. *Journal of Experimental Psychology-Learning Memory and Cognition, 23,* 932-945.

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology, 73*(3), 291-316.

Beishuizen, J.J., Wilhelm, P., & Schimmel, M. (2004). Computer-supported Inquiry Learning: Effects of training and practice. *Computers and Education, 42*, 4, 398 - 402.

Bransford, J. D. & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior, 11,* 717 - 726.

Chi, M.T.H., & VanLehn, K.A. (1991). The content of physics self explanations. *The Journal of the Learning Sciences, 1, 1,* 69-105.

Craik, F. I. M. & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 671-684.

Elshout, J.J. (1987). *Problem solving and education.* In E. de Corte, H. Lodewijks, R. Parmentier, & P. Span (Eds.), Learning and Instruction (pp. 259-273). Oxford: Pergamon Books Ltd.

Ericsson, K. A. & Simon, H. A. (1980). Verbal reports as data. *Psychological- Review, 87,* 215.

Ericsson, K. A. & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data (rev. ed.)*. Cambridge: MIT Press.

Gleitman, H. (1991). *Psychology*. (Third ed.) New York: W.W. Norton & Company, Inc.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing Inferences During Narrative Text Comprehension. *Psychological Review, 101*(3), 371-395.

Haring, B. (2002). *Kaas & de evolutietheorie [Cheese and the Theory of Evolution]*. (Third ed.) Antwerp: Houtekiet/Fontein.

Hyona, J., & Nurminen, A. M. (2006). Do adult readers know how they read? Evidence from eye movement patterns and verbal reports. *British Journal of Psychology, 97*, 31-50.

Linderholm, T., Everson, M.G., van den Broek, P., Mischinski, M., Crittinden, A., & Samuals, J. (2000). Effects of causal text revisions on more- and less-skilled readers' comprehension of easy and difficult texts. *Cognition and Instruction, 18*, 525-556.

Marton, F. & Saljö, R. (1997). Approaches to learning. In F. Marton, D. Hounsell, & N. Entwistle (Eds.), *The experience of learning: Implications for teaching and studying in higher education* (2nd ed., pp. 39-58). Edinburgh, Great Britain: Scottish Academic Press.

McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction, 14*(1), 1-43.

Narvaez, D., Van den Broek, P., & Ruiz, A. B. (1999). The Influence of Reading Purpose on Inference Generation and Comprehension in Reading. *Journal of Educational Psychology, 91*(3), 488-496.

Olshavsky, J. E. (1976). Reading as problem solving: An investigation of strategies. *Reading-Research-Quarterly,* 654-674.

Peterson, P., Swing, S., Braverman, M., & Buss, R. (1982). Students' aptitudes and their reports of cognitive processes during instruction. *Journal of Educational Psychology, 74,* 535-547.

Prins, F.J., Busato, V.V., Elshout, J.J., & Hamaker, C. (1998). Een nieuwe bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen (ILS). [A new contribution to the validation of the (meta) cognitive part of the Inventaris Leerstijlen (ILS).] *Pedagogische Studiën, 75* , 73-93.

Prins, F.J., Busato, V.V., Hamaker, C., & Visser, K.H. (1996). Een bijdrage tot validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen. [A contribution to the validation of the (meta)cognitive part of the Inventaris Leerstijlen.] *Pedagogische Studiën, 73*, 108-122.

Prins, F.J., Veenman, M.V.J., & Elshout, J.J. (2006) The impact of intellectual ability and metacognition on learning: New support for the threshold of problematicity theory. *Learning and Instruction,* 16(4), 374-387.

Rapp, D.N., Van den Broek, P. (2005). Dynamic text comprehension. An integrative view of reading. *Current directions in psychological science, 14(5)*, 276-279.

Schmeck, R. R. & Geisler-Brenstein, E. (1989). Individual differences that affect the way students approach learning. *Learning and Individual Differences, 1,* 85-124.

Simon, D. & Simon, H. A. (1988). Individual differences in solving physics problems. In R. Siegler (Ed.), *Children's thinking: What develops?* (pp. 325 - 348). Hillsdale, NJ: Erlbaum.

Trabasso, T., & Suh, S. (1997). Using think-aloud protocols to reveal readers' understanding of and responses to narratives. In S. Totosy de Zepetnek (Ed.), *The systemic and empirical approach to literature and culture as theory and application* (Vol. 7 pp. 527-547). Edmonton: University of Alberta, Research Institute for Comparative Literature and Cross-Cultural Studies.

Van den Broek, P, Rapp, D.N. Rapp, Panayiota, P. (2005) Integrating Memory-Based and Constructionist Processes in Accounts of Reading Comprehension. *Discourse processes 32* (2&3), 299-316.

Van den Broek, P., Virtue, S., Everson, M. G., Tzeng, Y. S., & Sung, Y. T. (2002). Comprehension and the memory of science texts. In A. C. Graesser, J. A. Leon & J. Otero (Eds.), *The Psychology of Science Text Comprehension* Mahwah, N.J: L. Erlbaum Associates, 2002.

Van Hout Wolters B.H.A.M.(1986). *Markeren van kerngedeelten in teksten [Marking core parts of study texts]*. Lisse: Swets & Zeitlinger.

Van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The think aloud method: A practical guide to modelling cognitive processes.* Academic Press.

Veenman, M. V. J., & Beishuizen, J. J. (2004). Intellectual and metacognitive skills of novices while studying texts under conditions of text difficulty and time constraint. *Learning and Instruction*, *14*, 619-638.

Veenman, M. V. J., & Elshout, J. J. (1995). Differential effects of instructional support on learning in simulation environments. *Instructional Science*, *22*, 363-383.

Vermunt, J. D. H. M. & van Rijswijk, F. A. M. W. (1988). Analysis and development of students' skill in self regulated learning. *Higher Education, 17,* 647-682.

Vermunt, J.D.H.M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken* [Learning styles and guiding learning processes in higher education]. Amsterdam: Swets & Zeitlinger.

Vermunt, J.D.H.M. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology, 68*, 149-171.

Vermunt, J.D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction,* 9(3), 257-280.

Chapter 3 Processing theory descriptions and examples in a linear expository text[2]

Abstract

Background. This study is a follow-up of Beishuizen et al. (2002). The main difference with respect to that study is that example paragraphs and theory paragraphs are treated as counterparts. That is, there is equal (little) opportunity to study examples or theory paragraphs, whereas in the previous study the indispensability was tested of one of the types of paragraphs, examples in that case.
Aims. This study explores the effects of manipulating the amount and order of theory paragraphs and example paragraphs in study texts, taking into account that students differ with respect to their Concrete Elaboration learning style (Vermunt, 1992, 1998), the habit of spontaneously generating examples when encountering theoretical explanations in a study text.
Samples. In all three experiments reported here 11th grade students were included.
Methods. Experiment 1 was required to eliminate the possibility of medium effects with respect to posttest scores. In experiment 2, the paragraph reading times were flexible and paragraph reading times were registered. In experiment 3 the paragraph reading times were fixed and readability judgments were registered. The text presented to the student was on the subject of human memory.
Results. With respect to posttest scores no difference was found between studying from paper or from screen. Subsequent experiments revealed that chapters with many theories are more difficult to understand and are judged more difficult than chapters with many examples.
Conclusion. Examples make a study text easier to read, but should be followed by a theoretical frame of reference. Both examples and theoretical concepts are indispensable in a study text but examples should precede theoretical explanations.

[2] Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). *Processing theory descriptions and examples in a linear expository text.*

Introduction

A textbook author, writing a chapter on human perception for an introductory textbook on psychology, has to explain that the perceptual mechanisms of constancy of size and shape sometimes produce illusions. The audience consists of readers without any expertise in psychology. How do writers structure the passage? Do they start with a definition, for instance: "The perceptual strategy of compensating for distance when perceiving size sometimes backfires and produces illusions" (Gleitman, 1991), and do they subsequently provide examples, both in text and in illustrations, for instance by showing the moon illusion, the Müller-Lyer illusion and the Ponzo illusion? Or do writers start with showing the illusions, and proceed with an explanation, ending with a definition of perceptual illusions? Approaching this problem from the position of the student, one may ask how students go along when they read a passage on inappropriate perceptual compensation. Do they start with processing a definition or theoretical explanation as a basis for understanding the examples in the text? Do they activate personal experiences triggered by the definition of perceptual illusions? Or do they use the examples in the text and associated personal experiences as an anchor for building an internal representation of the concept of perceptual illusions by extracting common elements out of the examples and experiences and using the definition in the text as a guide during the induction process? Textbook writers, as well as teachers in front of a class or researchers in front of a conference audience have to face the problem of setting in order theoretical explanations and examples in order to communicate a message. Perhaps, there is no simple answer to this problem, because readers differ in the way they construct knowledge out of oral or written explanations. In that case, the presentation should be adapted to the characteristics of individual students.

The aim of the experiment reported here was to study the effects of manipulating the amount and order of theory paragraphs and example paragraphs in study texts, taking into account that students differ with respect to their Concrete Elaboration (CE) learning style (Vermunt, 1992, 1998), the habit of spontaneously generating examples when encountering theoretical explanations in a study text. Three questions were put forward:

1. What is the effect of manipulating the number of example paragraphs and theory paragraphs in chapters of an expository text? Do students understand a chapter better when example paragraphs outnumber theory paragraphs or should the numbers be reversed?
2. What is the effect of manipulating the position of theory and example paragraphs in a chapter? Do students understand the chapter better when they first encounter example paragraphs and subsequently study theory paragraphs or should the order be reversed?

3. Are the effects of number and position of theory and example paragraphs dependent on the learning style of the student? Do high Concrete Elaboration (CE) students take theory paragraphs as point of departure whereas low Concrete Elaboration (CE) students try to grasp as much of the text as possible, irrespective of the type of paragraph they study?

Beishuizen, Stoutjesdijk, Spuijbroek, Bouwmeester, & Van der Geest (2002) have attempted to answer the question of whether examples or main ideas are indispensable in a study text by removing all examples and reformulating main ideas at an abstract level to impede comprehension by linking main ideas to known examples or concepts. In this way they tried to replicate the original experiment by Bransford and Johnson (1972) who prepared a text on washing clothes in a washing machine by substituting all concrete referents like “clothes” with abstract terms like “items”. Beishuizen et al. (2002) prepared two texts, which were difficult or impossible to comprehend. The authors concluded that examples help students to comprehend a text, but are not indispensable (Beishuizen et al., 2002). So, there might be two ways to comprehend a study text. The first way is the inductive approach: examples to concepts. Students understand the meaning of concepts by comparing examples in the text and extracting common elements. The second way is the deductive approach: Main ideas to examples. Students may link main ideas to examples, which are provided by the text. In our analysis of text comprehension we assume a functional similarity between examples in the text and episodes of personal experience. Students use both examples and episodes of personal experience to test their understanding of the concepts and principles that are represented by the main ideas in the text.

An inductive approach to text comprehension would be facilitated by a study text of a concrete content with many examples. Readers adopting an inductive approach might prefer to start the process of text comprehension by studying examples pertaining to a particular concept or principle. So, an example-oriented text format appears more appropriate for inductive text comprehension than an idea-oriented text format. Conversely, for deductive text comprehension abstract study texts appear more appropriate than concrete texts because an abstract text might initiate the process of example generation. If there are two ways of text comprehension (induction and deduction), then one can easily envision two kinds of students: Those who habitually adopt the deductive approach, and those who habitually adopt the inductive approach. Chi and VanLehn (1991) showed that students, studying physics examples, generated two kinds of explanations. The first type of explanation was created by a deductive approach: instantiating a main idea with information in the example statement. The second type of explanations was arrived at by way of an inductive approach: generalization and extension of the example statement.

However, instead of this induction version deduction explanation of the process of understanding expository texts, one could envision an alternative dichotomy. According to the adaptation versus accumulation explanation, some readers, encountering a concept in a study text, adapt their existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many examples. Other readers do not activate existing knowledge to the same extent and try to accumulate as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

Vermunt (1992) included in his Inventory of Learning Styles a scale named Concrete Elaboration, which assesses the extent to which students have the habit of spontaneously generating examples when they encounter main ideas in a study text. Vermunt (1992) defined Concrete Elaboration as “relating course contents to concrete things that are already known, such as personal experiences, concrete visual images, events in daily reality, practical applications” (p. 650). Students with a high score use the course content to generate concrete examples of everyday practice out of their personal experience. This approach is akin to the deductive approach and probably refers to abstract, idea-oriented study texts. But what about a low score on the Concrete Elaboration scale and other types of study texts? Are students with a low score simply not used to relating course contents to episodes of personal experience or do they habitually work along the inductive approach, extracting the meaning of concepts and principles from examples in the text and from personal experience? To put it differently, does the concrete elaboration dimension juxtapose the habits of deductive versus inductive text comprehension? Or does the concrete elaboration dimension represent the adaptation versus accumulation explanation, and are students with a high score more inclined to adapt their existing knowledge, whereas students with a low score do not operate strategically but merely try to accumulate as much knowledge as possible? Vermunt (1992) did not discuss these two possible interpretations.

Jonker, Beishuizen, and Veenman (submitted) asked secondary school students to read and think aloud whilst studying a relatively difficult text on the topic of perception and attention and a relatively easy text on evolution theory. Students displayed a lot of deductive reasoning, using the abstract concepts in the text to activate their own examples and experiences. Both high and low CE students showed this tendency, although high CE students particularly favoured this way of learning during studying the perception and attention text. The relatively easy evolution text elicited many conceptual elaboration in theory paragraphs and instance elaborations in example paragraphs, particularly by low CE students. All in all, the data gave more support to the adaptation versus accumulation hypothesis than to the induction versus deduction hypothesis.

In the experiment reported here, we wanted to continue with this line of research by combining two variables in one text: (1) The number of theory paragraphs and example paragraphs in a chapter and (2) the ordering of theory paragraphs and example paragraphs in a chapter. We constructed an expository text with four types of chapters:

(a) Theory chapters with four theory paragraphs, followed by one example paragraph (TTTTE);

(b) Theory chapters with one theory paragraph, followed by four example paragraphs (TEEEE);

(c) Example chapters with one example, followed by four theory paragraphs (ETTTT);

(d) Example chapters with four examples, followed by one theory paragraph (EEEET).

In accordance with Beishuizen et al. (2002), we expected a favourable effect of the availability of examples: TEEEE and EEEET chapters would need less time to read and would be better understood than ETTTT and TTTTE chapters. In accordance with Jonker, Beishuizen, and Veenman (submitted), we expected an interaction between learning style and chapter type: High CE students would read faster through and would learn more from chapters starting with a theory paragraph (TTTTE and TEEEE), whereas CE students would not display a particular preference for the chapters with many theories or chapters with many examples. They were expected to accumulate all information they were able to process.

Both hypotheses were tested by presenting an expository text of eight chapters (two of each type) to secondary school students. They had to study the text as if they were preparing for an ordinary test. Reading times per paragraph were recorded. The posttest consisted of separate questions for each of the eight chapters. Because we wanted to compare reading times by administering the texts through a computer and on-line recording of the time participants spent on each of the paragraphs in the text, we decided to run a preliminary experiment to check whether reading from screen and reading from paper were exchangeable as far as students' performance on a comprehension posttest was concerned.

Experiment 1. Reading an expository text from screen or from paper – a comparison

Research questions

Reading from a computer screen has been demonstrated to be slower than reading from paper. Dillon (1992) produced in his seminal review an estimate of 20% longer reading time for reading from a Cathode Ray Tube (CRT) screen. However, the technical conditions for presenting information on a computer screen have been drastically improved. Refresh rates, luminance, contrast have all been improved, which makes the outcomes of Dillon's (1992) review rather outdated. Recently, Noyes and Garland (2003) have compared reading times and performance on a comprehension of undergraduate students reading a study text from paper or from screen. Noyes and Garland (2003) found no significant differences in reading times or comprehension scores, but noticed that students in the screen condition qualified more of their answers on the posttest as “remembering” and less as “knowing” in comparison with the students from the paper condition. This may indicate, as the authors suggest, that a computer screen poses a heavier load on processing capacity, which has a negative effect on storage in long-term memory, and, consequently, lowers the “know” awareness rating, in favour of the “remember” rating.

In this study, we compared comprehension scores of two groups of secondary school students, one reading from a screen and the other one reading from paper. Both groups studied the same text on human memory. In accordance with Noyes and Garland (2003), we expected no differences on the posttest scores.

Method

Participants

Students came from two different samples. The paper group of 96 (79 females, 17 males) secondary school students (mean age 16.88, sd= .62), studied a text on human memory at home, preparing for an information meeting on choosing an academic career after finishing secondary school. The students came from various secondary schools and participated voluntarily in the information session. The computer group of 39 (17 female, 22 male; age 16.91, SD = .51) secondary school students participated voluntarily in the experiments to be reported in the subsequent part of this paper.

Materials

<u>Experimental Text</u>. For the purpose of this experiment an experimental text (in Dutch) on the topic of human memory was constructed. The text consisted of eight chapters. Each chapter contained an introduction and five paragraphs. Table 2 contains an example of an introduction, a theory paragraph and an example paragraph.

<u>Posttest</u>. The posttests for screen and paper participants were not identical. Both groups studied the same text, but the paper group completed a posttest consisting of 24 questions over 8 chapters, whereas the posttest administered to the computer students consisted of 24 questions over only 6 chapters. For the purpose of comparing comprehension performance after reading a study text from screen or from text, posttest results were confined to the 18 questions about 6 chapters, which both groups completed in their test. Cronbach’s alpha over these 18 questions was .71.

Results

Table 1 shows the means and standard deviations for participants who studied from screen (*n* = 39) and the participants who studied from paper (*n* = 96). In fact, the differences in comprehension scores of the two groups, as measured on the posttest, was exceptionally small (F = .00, p = .98), irrespective of the type of chapter under consideration.

Table 1. Posttest Scores of Students who Read the Study Text on Human Memory from Screen or from Paper.

	Medium			
	Screen n = 39		Paper n = 96	
Chapter Type	*M*	*sd*	*M*	*Sd*
TTTTE	0.62	0.27	0.58	0.32
ETTTT	0.62	0.29	0.64	0.32
EEEET	0.63	0.27	0.65	0.30
TEEEE	0.59	0.28	0.59	0.29

Conclusions

No difference was found in text comprehension between the two different groups of students who studied either from computer screen or from paper. Studying from screen does not bear advantages or disadvantages compared to reading from paper. However, two statements of caution should be emphasized here. First, this result is exclusively based on the posttest results. There is no reading time or other process data available for the text on paper. Secondly, we did not collect any evidence on awareness ratings, revealing differences in cognitive processes linked with the “Remember” feeling and the “Know” feeling, as was done by Noyes and Garland (2003). Despite these reservations, our findings support Noyes and Garland’s (2003) conclusion that reading from an advanced computer screen does not impede understanding of an expository text. Therefore, we decided to continue the following studies with presenting texts on computer screens allowing us to collect on-line processing data.

Experiment 2: Flexible reading times

Hypotheses

In this experiment we compared reading and comprehension performance of high and low CE students whilst studying an expository text on human memory from a computer screen. We recorded reading times per paragraph and scores on a comprehension posttest. In accordance with the studies reported in the general

introduction we expected that students spend more time on reading chapters with many theory paragraphs than chapters with many example paragraphs.
High CE students perform better (shorter reading times and higher posttest scores) on chapters with many theory paragraphs than on chapters with many example paragraphs.

High CE students perform worse (longer reading time times, lower posttest scores) on chapters with many examples *starting* with a theory paragraph than on chapters with many examples *ending* with a theory paragraph.
Low CE participants do not display a differentiated profile of good performance or poor performance when studying chapters with many theories of many examples and completing comprehension questions about these chapters.

Method

Participants

Forty 11th grade secondary school students (mean age 16.92, SD = .52), 18 female and 22 male, participated in the experiment on a voluntary basis. They received a small remuneration for their participation.

Materials

Experimental Text. For the purpose of this experiment an experimental text (in the Dutch language) on the topic of human memory was constructed. The text consisted of eight chapters. Each chapter contained an introduction and five paragraphs. Table 2 contains an example of an introduction, a theory paragraph and an example paragraph. The experimental text contained four types of chapters:
(a) Chapters with four theory paragraphs, followed by one example paragraph (TTTTE);
(b) Chapters with one theory paragraph, followed by four example paragraphs (TEEEE);
(c) Chapters with one example, followed by four theory paragraphs (ETTTT);
(d) Chapters with four examples, followed by one theory paragraph (EEEET).
For each type of chapter the text contained two chapters. A paragraph contained on average 150 words. The text had to be read from a computer screen and was presented one paragraph at a time.
Learning Styles Inventory. The Concrete Elaboration Scale of Vermunt's (1992, 1998) Inventory of Learning Styles was used (see appendix) to measure the students' habit of giving concrete form to what they read. The five-point scale consisted of five relevant statements and five filler statements. On the five items of the five-point scale, students scored on average 13.70 (*SD* = 3.56). The reliability coefficient of this short inventory was satisfactory (Cronbach's alpha = .68). Students with a score below the median (13) were allocated to the low concrete elaboration subgroup. All remaining students were allocated to the high concrete elaboration subgroup.

Posttest. The posttest contained 24 multiple-choice questions, four questions per chapter. The questions required the student to match a description of a concept or rule with an example of the concept or rule or, alternatively, match an example with a description of a concept or rule.

Table. 2. Examples Taken from the Chapter on Semantic and Episodic Memory of the Experimental Text on Human Memory: an Introductory Paragraph, a Theory Paragraph and an Example Paragraph.

Introductory paragraph
We are used to regard the long-term memory as a huge reservoir, containing all knowledge and experiences, that is stored in our memory for a long time or even for ever. However, in the psychology of memory all sorts of categorizations have been made. Tulving (1972) was the first to make the distinction between episodic and semantic memory. Episodic memory is the memory for specific events in someone's memory, events are linked to a specific time and place. Semantic memory contains all our acquired knowledge. Knowledge of facts, concepts, schemas and procedures, which is not linked to a specific time or place, but disjoined from time and place by abstraction.
Theory paragraph
What is the most important difference between the content of the episodic and the content of the semantic memory? The knowledge stored in semantic memory is disjoined from time and place. In order to activate a memory from episodic memory one can ask someone: "Do you remember the following occurrence: ...?". In order to activate semantic memory one could ask someone: "Do you know the meaning of the following idea: ...?" The verb "to remember" alludes to the activation of a memory content in episodic memory, while the verb "to know" alludes to the activation of a memory content from semantic memory. Knowledge in semantic memory is disengaged from time and place. One could also say that knowledge in semantic memory is abstract and decontextualized.
Example paragraph
When you ask your friend: "Do you remember where you were when you heard the news about the attack of the World Trade Center on September 11th 2001?", your friend needs to consult his episodic memory. However, when you ask the question: "Do you know the difference between a dromedary and a camel?", your friend needs to consult his semantic memory. The question "Do you remember what a paprika is?" sounds rather strange. With "to remember" one thinks of episodic memory, with "to know" one thinks of semantic memory. Knowledge of language is also situated in semantic memory. Anything you learned at school is stored in semantic memory. When you are requested to answer the question "Who were Napoleon's opponents at battle of Waterloo?" you can proceed in two different ways. You could try to activate your knowledge of Napoleon and the political situation at the end of Napoleon's regime. Or you can try to remember on which page in the textbook, or even in which figure, the battle of Waterloo is described. In the former strategy you consult your semantic memory, in the latter your episodic memory.

Procedure

Students were asked to study the text from a computer screen as if they were preparing for an exam. The Inventory of Learning Styles and the posttest were administered afterwards. During the study session, reading times per paragraph were recorded. In order to prevent contamination between chapter content and chapter type, four versions of the study text were constructed in which the type of the chapters was varied according to a Latin square. Students were randomly assigned to a text version.

Results

Two repeated measures analyses were conducted with level of concrete elaboration as between-subjects variable and chapter content (many theories or many examples) and paragraph order (theory first or example first) as within-subject variables. In the first analysis reading time per chapter was included as the dependent variable, while in the second analysis we took the posttest score per chapter as dependent variable.

Reading speed

It was expected that chapters with many theories would take more time to read than chapters with many examples. Moreover, low CE students were expected to need more time to study chapters beginning with a theory paragraph than high CE students. For chapters beginning with an example we expected that low CE students would proceed faster through the text than high CE students.

Reading times per chapter type and level of concrete elaboration are displayed in Table 3. The difference in reading time between chapters with many examples and chapters with many theories turned out significant (F (1, 29) = 20.48, $p < .01$). Chapters with many theory paragraphs took more time to read (M = 464.31 sec, SD = 93.76) than chapters with many example paragraphs (M = 410.60 sec, SD = 83.93). There was no significant paragraph order effect (F (1, 29) < 1). The interaction between chapter content and level of concrete elaboration was significant (F (1, 29) = 6.19, $p < .05$). Figure 1 shows the interaction. Chapters with many theories took low CE students considerably more time to read than high CE students.

Table 3. Reading Times in Seconds per Chapter Type and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low *n* = 21		High *n* = 19	
Chapter Type	*M*	*sd*	*M*	*sd*
EEEET	417.33	95.96	390.44	86.36
TEEEE	371.13	79.95	399.56	107.70
TTTTE	465.33	98.98	404.56	149.83
ETTTT	491.00	139.17	434.19	95.68

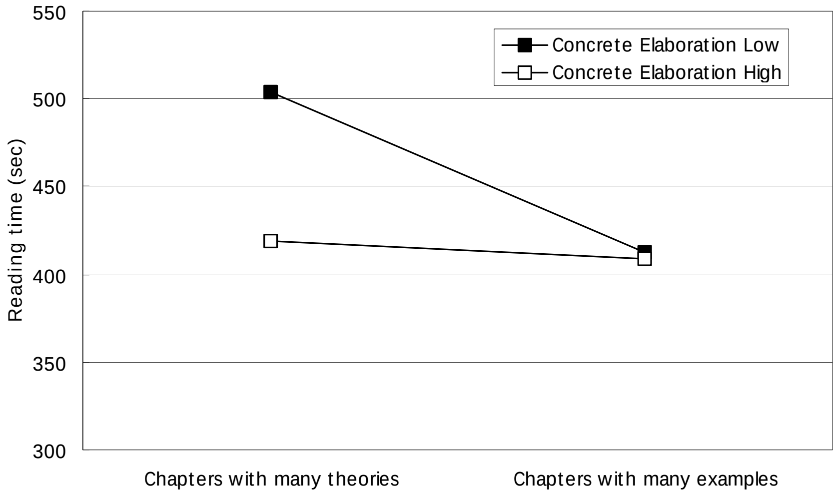

Figure 1. Interaction between Chapter Type and Level of Concrete Elaboration.

Text comprehension

It was expected that chapters with many theories would be more difficult to understand than chapters with many examples. Moreover, low CE students were expected to have more trouble understanding chapters beginning with a theory paragraph than high CE students. For chapters beginning with an example we expected that low CE students would understand the text better than high CE students.

Posttest scores per chapter type and level of concrete elaboration are displayed in Table 4. Unexpectedly, neither effects of chapter content or paragraph order showed up, nor was any of the interactions between the text variables and level of concrete elaboration significant. Although Figure 2 gives the impression that low CE students performed worse on questions about chapters with many theories than high CE students, due to large within group variance this effect was not significant (F (1, 37) = 1.63, p = .21). The same held for the apparent difficulty of chapters with many examples starting with an example paragraph in comparison with chapters with many examples starting with a theory paragraph. Again, due to large within group variance, the difference turned out not significant (F (1, 37) = 1.92, p = .17). Within the group of high CE students, scores on chapters with many theories were higher (M = .75, SD = .18) than scores on chapters with many examples (M = .69, SD = .25), but the difference was not significant (t (17) = 1.05, p < .31). Within the group of high CE students, the difference in scores on chapters with many examples, *starting* with theory paragraph (M = .66, SD = .32) and chapters with many examples, *ending* with a theory paragraph (M = .71, SD = .27) was in the expected direction, but not significant (t (17) = .81, p < .43).

Table 4. Posttest Scores per Chapter Type and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low *n* = 21		High *n* = 18	
Chapter Type	*M*	*Sd*	*M*	*sd*
EEEET	0.74	0.29	0.71	0.27
TEEEE	0.64	0.28	0.66	0.32
TTTTE	0.68	0.26	0.75	0.23
ETTTT	0.62	0.34	0.75	0.31

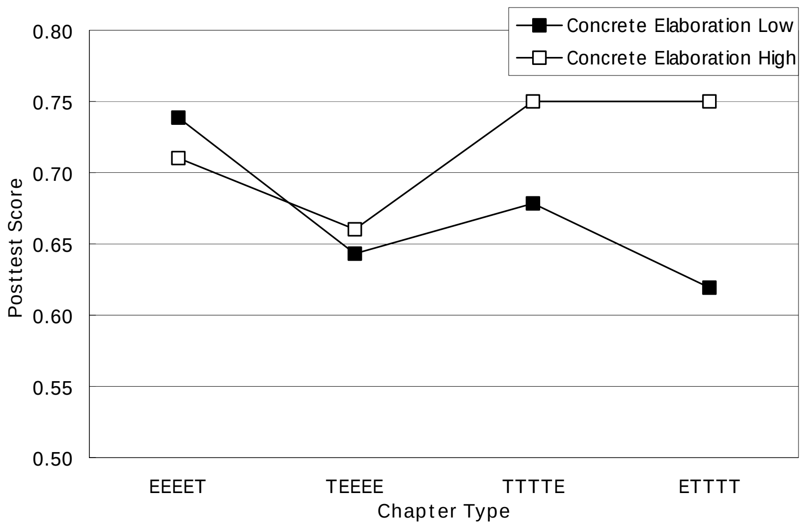

Figure 2. Posttest Scores per Chapter Type and Level of Concrete Elaboration

Discussion

We found support for the prediction that students spend more time on chapters with many theory paragraphs than chapters with many example paragraphs. Reading times significantly differed in the expected direction. However, there were no significant differences in reading times of high CE student studying chapters with many theory paragraphs and chapters with many example paragraphs. Differences in posttest scores went into the expected direction but were not significant. Looking at the chapters containing many example paragraphs, the order of these chapters, either beginning or ending with a theory paragraph, did not show a difference. The data showed that low CE students spent more time on chapters with many theory paragraphs than on chapters with many example paragraphs. Differences in posttest scores between the four chapter types were more pronounced for low CE students than for high CE students, however, not significant in either case. In summary, except for the reading time differences, the data did not corroborate our initial expectations.

Before arriving at final conclusions, we wanted to verify that differences in reading times did not reduce differences in posttest scores. When students adapt their reading strategies to the encountered difficulty of the chapters, then shorter reading times for easy chapters may result in the same performance level on the posttest as longer reading times on difficult chapters. Therefore, we decided to run another experiment in which students completed a comprehension test after they had studied the individual paragraphs for a fixed amount of time. During the text studying session, we asked the students to rate each chapter on a readability scale.

Experiment 3: Fixed reading times

Hypotheses

In this experiment we compared reading and comprehension performance of high and low CE students whilst studying an expository text on human memory from a computer screen under the condition of a fixed period of 90 seconds per paragraph. We recorded readability judgments per chapter and scores on a comprehension posttest. In accordance with the studies reported in the general introduction we expected that:

Students judge chapters with many theory paragraphs as more difficult to read than chapters with many example paragraphs.

High CE students produce higher readability ratings and higher posttest scores on chapters with many theory paragraphs than on chapters with many example paragraphs.

High CE students produce lower readability ratings and lower posttest scores on chapters with many examples *starting* with a theory paragraph than on chapters with many examples *ending* with a theory paragraph.

Low CE participants do not display a differentiated profile of low or high readability ratings and posttest scores when studying chapters with many theories of many examples and completing comprehension questions about these chapters.

Method

Participants

Seventy-nine 11th grade secondary school students, 39 female and 40 male, participated in the experiment on a voluntary basis. Thirty-nine students came from a school in Leiden and forty from a school in Amsterdam. They received a small remuneration for their participation. The average age of the students was 16.6 years (*SD* = .64).

Materials

All materials (Experimental text, Learning Styles Inventory, and Posttest) were identical to those used in Experiment 2.

Procedure

Students were asked to study the text from a computer screen as if they were preparing for an exam. During the study session, students received 90 seconds to study each paragraph. After studying a chapter, students were asked to rate the readability of the chapter on a five-point scale, ranging from 1 (easy to understand) to 5 (hard to understand). The Inventory of Learning Styles and the posttest were administered afterwards. In order to prevent contamination between chapter content and chapter type, four versions of the study text were constructed in which the type of chapters was varied according to a Latin square. Students were randomly assigned to a text version.

Results

Two repeated measures analyses were conducted with level of concrete elaboration as between-subjects variable and chapter content (many theories or many examples) and paragraph order (theory first or example first) as within-subject variables. In the first analysis readability judgment per chapter was the dependent variable, while in the second analysis posttest score per chapter was included as dependent variable.

Readability Judgments

Readability judgments per chapter type and level of concrete elaboration are displayed in Table 5. The difference in readability judgments between chapters with many examples and chapters with many theories turned out significant (F (1, 36) = 80.82, $p < .01$). Chapters with many theory paragraphs were considered more difficult (M = 2.11 sec, SD = .06) than chapters with many example paragraphs (M = 1.69 sec, SD = .06). Calculated over the individual paragraphs, reading times, collected in the previous experiment, and readability judgments were positively correlated, r = .76. There was no significant paragraph order effect (F (1, 36) = 1.87, p = .18). The interaction between chapter type and chapter order was significant (F (1, 36) = 8.49, $p < .01$. Within the chapters with many theories, the chapters starting with a theory paragraph were considered more difficult (M = 2.19, SD = .07) than the chapters starting with an example (M = 2.03, SD = .07). The interaction between chapter type and level of concrete elaboration was also significant (F (1, 36) = 4.30, $p < .05$). High CE students considered chapters starting with an example easier to understand than low CE students.

Table 5. Readability Judgments on a Five Point Scale (1 = Easy to Understand; 5 = Hard to Understand) per Chapter Type and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low *n* = 23		High *n* = 15	
Chapter Type	*M*	*Sd*	*M*	*sd*
EEEET	1.81	.46	1.60	.37
TEEEE	1.71	.36	1.65	.35
TTTTE	2.19	.43	2.20	.44
ETTTT	2.16	.38	1.89	.42

Text Comprehension

A repeated measures analysis was conducted with level of concrete elaboration as between-subjects variable and chapter type (many theories or many examples) and paragraph order (theory first or example first) as within-subject variables. The posttest score per chapter was the dependent variable. Table 6 shows the figures for each of the eight experimental groups. No main effects or interaction effects turned out significant.

A between subjects comparison of the posttest scores under the free reading condition of the previous experiment and the fixed reading time condition of this experiment revealed a significant effect of Reading Condition (F (1, 113) = 5.70, $p < .05$). Students produced a higher posttest score (M = .69, SD = .18) under the free reading time condition than under the fixed reading time condition (M = .62, SD = .14). Table 7 presents the data. There were no significant effects of Level of Concrete Elaboration ($F < 1$), nor was the interaction between Reading Condition and Level of Concrete Elaboration significant ($F < 1$).

Table 6. Posttest Scores per Chapter Type and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low *n* = 44		High *n* = 34	
Chapter Type	*M*	*sd*	*M*	*sd*
EEEET	.63	.26	.69	.23
TEEEE	.61	.22	.59	.25
TTTTE	.61	.22	.59	.25
ETTTT	.63	.26	.60	.23

Table 7. Posttest Scores per Reading Condition (Free, Fixed) and Level of Concrete Elaboration.

	Concrete Elaboration					
	Low			High		
Reading Condition	*n*	*M*	*sd*	*n*	*M*	*sd*
Free Reading Time	21	.67	.17	18	.72	.18
Fixed Reading Time	44	.62	.12	34	.62	.16

Discussion

Support was found for the prediction that chapters with many theory paragraphs were judged more difficult to read than chapters with many example paragraphs. Paragraphs, which took a lot of time to read in the previous experiment, were considered as difficult in this experiment. Moreover, an overall interaction between Chapter Type and Paragraph Order was found. Of the four distinguished combinations of chapter type and paragraph order, all students considered chapters with many theories, *starting* with a theory paragraph, the most difficult to understand. Consequently, our hypothesis that the learning style adopted by the student would influence the readability judgments of theory chapters with various paragraph orders was not confirmed.

No differences in readability ratings between theory and example chapters were found. However, high CE students considered both theory and example chapters starting with an example paragraph easier to understand than low CE students. This confirms both hypotheses about the readability ratings of high CE students. No effects on reading comprehension were found.

The main effect of Type of Chapter on readability ratings does not give support to our prediction about low CE students. Low CE students, as well as high CE students, considered chapters with many theory paragraphs as more difficult to comprehend than chapters with many examples.

In sum, the readability judgments of high and low CE students studying chapters with many theory or many examples paragraphs, *starting* with a theory paragraph or an example paragraph, partially met with our expectations. Chapters with many theory paragraphs were considered as more difficult to understand than chapters with many examples. Paragraphs, which took a lot of time to read in the previous experiment, were considered as hard to read in this experiment, as there was a high positive correlation between reading time and reading difficulty of paragraphs. High CE students did consider all chapters starting with a theory paragraph as harder to understand than chapters starting with an example paragraph. This gives support to the suggestions of Beishuizen et al. (2003) that high CE students use a theory paragraph as a point of departure to activate their own examples and experiences. This activity interferes with further reading and understanding the examples in the text. Low CE students considered chapters with many theory paragraphs as more difficult to understand than chapters with many examples. It is not clear whether this disconfirms the adaptation versus accumulation explanation of the concept of concrete elaboration.

The lack of any effects of Type of Chapter or Paragraph Order on posttest scores is difficult to interpret. It is clear that our expectation that fixing reading times would increase the influence of text characteristics on reading comprehension was not met with. A comparison of the posttest performance under the free reading time condition and the fixed reading time condition revealed that fixing the reading time had a detrimental effect on reading comprehension. Taking into account that on a standard four-choice test the cut-off point may be set to 63% correct (25% for correct guessing plus 50% of the remaining 75%, in total 62.5%), then in the fixed reading time condition only the scores on the EEEET paragraphs would pass (Table 7), whereas in the free reading time condition only the scores of the low CE students on the ETTTT conditions would fail (Table 4). So, we have to conclude that setting the reading time to 90 seconds per paragraph prevented the students from comprehending the study text to a sufficient extent. Therefore, the lack of effect of text characteristics on reading comprehension may be due to a floor effect.

General discussion

The main finding of this study was that expository texts with many theory explanations and few examples take more time to read and are rated as more difficult than texts with many examples and few theory explanations, in particular by students low on concrete elaboration. This is in line with Begg & Paivio (1969) who suggest that concrete sentences allow better for unitisation than abstract sentences do. In other words, readers may be able to imaginably (re)code concrete sentences, whereas for abstract sentences, the reader has no such option. Hence, there is more to remember when reading abstract sentences, either when written in plain language or in some kind of proposition. Therefore longer reading times are required for studying abstract sentences.

However, these content effects were not confirmed by corresponding differences in comprehension scores. Under free reading time conditions, learning outcomes went into expected directions but differences were not significant. Under fixed reading time conditions, no differences in comprehension scores were found.

The lack of effects of text content and paragraph ordering on comprehension scores is difficult to interpret. The possibility exists that students used extra time for difficult passages in order to arrive at an appropriate level of understanding. If this interpretation were correct, then text effects and learning style effects would only show up in reading speed and not in text comprehension. Fixing reading times, however, does not allow students to spend more time on difficult passages in the text. In the third experiment, such condition of fixing reading times was implemented. Unfortunately, the reading times may have been too short to allow for proper understanding of the text, which, consequently, may have obscured any relationship between text characteristics and text comprehension.

The results of the reported experiments confirmed our understanding of high and low CE students, in that high CE students felt more comfortable with theory-oriented expository texts than low CE students, taken the process measures of reading times and perceived level of text difficulty into account. We found some indirect support for the findings of Beishuizen et. al (2003) that high CE students produced lower comprehension scores on theory chapters where examples were placed *after* theory descriptions in comparison to theory chapters where examples were placed *in front of* theory descriptions. In this study, high CE students considered theory chapters with an example in the first paragraph as easier to read than theory chapters with an example in the last paragraph.

The meaning of the concept of concrete elaboration has not been completely clarified. As far as high CE students are concerned, we find some support for the adaptation versus accumulation view, as Jonker, Beishuizen, and Veenman (submitted) concluded. High CE students spent more time on theory chapters than on example chapters and considered theory chapters as more difficult to read than example chapters. Under the condition of free reading time, their performance scores suggested a higher level of understanding. Low CE students showed the same profile but did not end up in better performance on a reading comprehension test.

The practical implication of these findings may be that students should be encouraged to actively adapt new information to existing knowledge by giving concrete form to abstract concepts in the text. Moreover, examples make a study text easier to read, but should be followed by a theoretical frame of reference. Both examples and theoretical concepts are indispensable in a study text but examples should precede theoretical explanations.

References

Begg, I., & Paivio, A. (1969). Concreteness and imagery in sentence meaning. *Journal of Verbal Learning and Verbal Behavior, 8*, 6, 821-827.

Beishuizen, J.J., Stoutjesdijk, E.T, Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology, 72*, 279 – 297.

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology*, *73(3*), 291-316.

Bransford, J. D. & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior, 11,* 717 - 726.

Chi, M.T.H., & VanLehn, K.A. (1991). The content of physics self explanations. *The Journal of the Learning Sciences, 1,* 1, 69-105.

Dillon, A. (1992). Reading from paper versus screens: A critical review of the empirical literature. *Ergonomics, 35*, 10, 1297 - 1326.

Gleitman, H. (1991). *Psychology*. (Third ed.) New York: W.W. Norton & Company, Inc.

Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). Understanding an expository text – a process analysis.

Noyes, J.M., & Garland, K.J. (2003). VDT versus paper-based text: Reply to Mayes, Sims and Kince. *International Journal of Industrial Ergonomics, 31,* 411-423.

Vermunt, J.D.H.M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken* [Learning styles and guiding learning processen in higher education]. Amsterdam: Swets & Zeitlinger.

Vermunt, J.D.H.M. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology, 68*, 149-171.

Chapter 4 Concrete elaboration and cognitive flexibility - understanding an expository hypertext[3]

Abstract

A hypertext maybe a solution to the problem that students have developed various learning styles with various preferred reading strategies. Students with a high score on Vermunt's (1992) Concrete Elaboration scale use a study text to generate concrete examples of everyday practice out of their own personal experience. In a hypertext environment, these students might prefer to start a chapter with reading theory paragraphs and may eventually skip the example paragraphs. Students with a low score on the concrete elaboration scale may either prefer to depart from examples or may not show clear preferences for either theory paragraphs or example paragraphs. Two experiments were carried out in order to relate an increasing level of freedom of choice to the learning style of Concrete Elaboration. Upper secondary school students studied a hypertext on aggression with a fixed sequence of chapters and freedom of choice from theory and example paragraphs within each chapter. The results show that students have to learn to grasp the opportunities for cognitive flexibility which a hypertext offers. When free to choose, students tend to prefer theory chapters over example chapters. Low Concrete Elaboration students have to actively break away from this orientation in other to develop their own reading strategy. A hypertext learning environment offers appropriate conditions to develop cognitive flexibility but also imposes a considerable amount of cognitive load on the reader. However, if there is room for such development, then students with various learning styles may eventually be able to grasp the opportunities and successfully complete their journey through the landscape of the ill structured domain.

[3] Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). *Concrete elaboration and cognitive flexibility - understanding an expository hypertext.*

Introduction

The Internet has become a very powerful and frequently used source of information for students in university, secondary, and even primary education. Imagine a student who has completed a course on psychoanalysis and has to write an essay on the differences in the way Freud and Jung treat the concept of aggression in their theoretical frameworks. She may go to the university library to consult textbooks dealing with psychoanalysis, aggression, Freud, and Jung. She may have to work her way through introductory chapters or systematic explanations of Freud's and Jung's theories. She may also consult the index pages of the books and check the entries of psychoanalysis, aggression, Freud, and Jung. There is, obviously, no way to intersect the search terms. An alternative approach is to use a search engine available through the Internet, e.g., PubMed. Entering search terms like "aggression", "Freud", and "Jung" brings the student to a collection of relevant publications which may subsequently be further searched and studied. One of the questions one may raise from an educational point of view is whether students differ in the ability and learning habits to use these ubiquitous facilities to such an extent that they end up with reliable and valuable information which they are able to understand and use in subsequent tasks, like writing an essay.

Several authors have discussed the pros and cons of using hypertext as a format for expository texts. The term "hypertext" has been coined by Nelson (1967) to denote every "non linear" text. In a hypertext readers have the opportunity to identify to which fragment they want to navigate after finishing the current fragment. There is no pre-determined linear order; every fragment ends with a list of options indicating which steps can be taken. McKnight, Dillon, & Richardson (1993) defined hypertext as "a fragmented text form whose components can be rapidly accessed" (p. 8). The psychological arguments in favour of using a hypertext in an educational context are twofold: (1) A hypertext forces the reader to actively process the content, and (2) a hypertext presents a knowledge domain in its full complexity.

Acquiring knowledge and skills is always the result of active participation in the process of extracting meaning from the text (knowledge) or active practice and rehearsal (skills). Learning is a by-product of understanding (McKnight, Dillon, & Richardson, 1993). Therefore, learning materials should always be presented in such a way, that students are forced to process the content actively. A hypertext requires constant concern about how to navigate through the text. When readers are forced to make decisions about where to go after a fragment has been studied, they will be supported in constructing a representation of the text (Kintsch, 1988), they will better understand the text and use the knowledge acquired from the text in a new task. Under these conditions they need to process the content deeply (Marton & Saljö, 1997), which fosters understanding (Bransford & Johnson, 1972).

Readers differ in the way they prefer to study an expository text (Beishuizen et al., 2002; Beishuizen et al., 2003; Jonker, Beishuizen, & Veenman, submitted). Accommodating for these individual differences in learning style (Vermunt, 1992, 1998) may foster understanding of study texts by students with various learning styles.

Rand Spiro developed a theory, the Cognitive Flexibility Theory, accounting for the beneficial effects of using hypertext in a context of knowledge acquisition (Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger, 1987; Spiro & Jehng, 1990; Jacobson & Spiro, 1995). According to the Cognitive Flexibility Theory, in ill structured domains, to which category most subject matter areas in social sciences, history, economy, geography belong, knowledge acquisition has it own characteristics which deviate from well structured domains like mathematics and logic. In ill structured domains no rules or principles can be formulated which are general and broad enough to cover all or even most of the cases under consideration. Understanding these rules or principles requires the construction of flexible, goal oriented and contextualized schemas. Schemas in a particular domain are highly overlapping and intertwined and should be interconnected as much as possible. Schemas should be accessible from many directions. In educating students to become familiar in these ill structured domains the emphasis should not be on simplicity but on complexity (Jacobson & Spiro, 1995). Cases should be studied in a natural context, not in a reduced environment. Students should not be misled by the impression that a complex domain is well structured and easy to master. An ill structured domain is like a landscape (in Wittgenstein's sense) which should be explored from different points of departure, by travelling from one case to another ("criss-crossing"). Restricting the student to one particular itinerary should be avoided. Therefore, non linear and multidimensional texts are the best representation of an ill structured domain. To summarize, Jacobson and Spiro (1995) offer five guidelines to prevent oversimplification of knowledge:

1. Use Multiple Conceptual Representations of Knowledge.
2. Link and Tailor Abstract Concepts to Different Case Examples.
3. Introduce Domain Complexity Early.
4. Stress the Interrelated and Web-Like Nature of Knowledge.
5. Encourage Knowledge Assembly.

It is clear that an expository text in hypertext format is an appropriate learning environment to prevent oversimplification of knowledge because readers are forced to reconsider their journey through the text every time they have finished reading a paragraph. In that respect a hypertext seems to be the solution to the problem that students have developed various learning styles with various preferred reading strategies. Vermunt (1992) included in his Inventory of Learning Styles a scale named Concrete Elaboration, which assesses the extent to which students have the habit of spontaneously generating examples when they encounter main ideas in a study text.

Vermunt (1992) defined Concrete Elaboration (CE) as “relating course contents to concrete things that are already known, such as personal experiences, concrete visual images, events in daily reality, practical applications” (p. 650). Students with a high score use the course content to generate concrete examples of everyday practice out of their own personal experience. In a hypertext environment, these students might prefer to start a chapter with reading theory paragraphs and may eventually skip the example paragraphs. Students with a low score on the concrete elaboration scale may either prefer to depart from examples or may not show clear preferences for either theory paragraphs or example paragraphs. The first alternative is an elaboration of the induction versus deduction explanation of the difference between high and low CE students; the latter is in accordance with the adaptation versus accumulation explanation.

According to the adaptation versus accumulation explanation, high CE students take their own knowledge as point of departure: On encountering a concept in a study text, they adapt existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many such examples. Low Concrete Elaboration students do not activate existing knowledge to the same extent and try to accumulate as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

The alternative deductive versus inductive learning explanation is inspired by Chi and VanLehn (1991) who showed that students, studying physics examples, generated two kinds of explanations: The first type of explanations indicated a deductive approach: Instantiating a general principle with information in the example statement. The second type indicated an inductive approach: Generalization and extension of the example statement. To put it differently, readers may reason either from general principles to examples by taking the principle as point of departure (the deductive approach), or from examples to general principles by abstracting general principles from examples (the inductive approach). Student s high on Concrete Elaboration adopt the deductive approach whereas students low on Concrete Elaboration prefer the inductive approach.

Jonker, Beishuizen, and Veenman (submitted) found moderate support for the adaptation versus accumulation explanation. They asked secondary school students to read and think aloud whilst studying a relatively difficult text on the topic of perception and attention and a relatively easy text on evolution theory. Students displayed a lot of deductive reasoning, using the abstract concepts in the text to activate their own examples and experiences. Both high and low CE students showed this tendency although high CE students particularly favoured this way of learning during studying the perception and attention text. The relatively easy evolution text elicited many conceptual elaborations in theory paragraphs and instance elaborations in example paragraphs, particularly by low CE students. All in all, the data gave more support to the adaptation versus accumulation hypothesis than to the induction versus deduction hypothesis.

Do readers actually use the opportunities offered by the facilities of a hypertext? Trumbull, Gay, and Mazur (1992) observed that "many potential users of hypertext systems lack the cognitive skills, the motivation or the attitude toward learning required to take full advantage of these complex systems". Often, the design of these systems prevents the proper use of the tools: Excessive links, confusing structures, absence of organizing metaphors. Trumbull, Gay, and Mazur (1992) prepared a text with three hypertext tools: An index with a list of topics, a browser with maps of chapters and a guide which suggested the next step to be taken. Most students preferred the browser to explore the text which enabled them to travel linearly through the text. It seems that readers consider the process of finding an appropriate route to explore an expository text as an extra source of cognitive load which should be avoided if possible. So, it is not clear from the outset that a hypertext with its opportunities for active knowledge construction will produce better understanding than a traditional linear text. Students may have to divide their attention and effort over the navigation task and the comprehension task or may simply not use the navigation facilities.

In this study we were interested in the relationship between the learning style of Concrete Elaboration (Vermunt, 1992, 1998) and the use of hypertext to study a topic. Two experiments were carried out in order to relate an increasing level of freedom of choice to the learning style of Concrete Elaboration. In Experiment 1, participants studied a hypertext on aggression with a fixed sequence of chapters and freedom of choice from theory and example paragraphs within each chapter. More freedom of choice was available in Experiment 2. The hypertext presented to the participants enabled them not only to divide their time and attention over the two types of paragraphs within each chapter, but here they were also free in the sequence of chapters to be studied.

Experiment 1. Studying an Experimental Hypertext with Free Choice of Theory and Example Paragraphs within a Chapter

In this experiment, upper secondary school students were presented with a text on human aggression. The text consisted of ten chapters, which had to be studied in a predetermined fixed sequence. Two fixed chapters consisted of an introduction and four theory paragraphs. Two fixed chapters consisted of an introduction and four example paragraphs. Within the remaining six hypertext chapters, students had the freedom to choose between four theory paragraphs and four example paragraphs. After studying the text students completed a comprehension test. In accordance with the literature referred to in the general introduction, we expected that students study

more theory paragraphs than example paragraphs. Moreover, we expected that, in chapters with freedom of paragraph choice, high CE students would start with theory paragraphs, and low CE students would start with example paragraphs.
Generally, we assumed that students would perform better on posttest questions about theory chapters than on questions about example chapters. However, this effect might be moderated by the learning style of the reader: High CE students might score higher on theory chapters, and low CE students might score higher on example chapters.

Method

Participants

A total of 106 students, 82 women and 24 men, participated in this experiment on a voluntary basis, without any reward. Mean age was $M = 16.60$ ($SD = 1.06$). The participants were fourth or fifth grade students from various secondary schools in the south-western part of the Netherlands, who came to Leiden University to participate in an orientation programme on the subject and study of psychology. For various reasons, the students preferred to subscribe to the psychology programme. They were hosted at the psychology department of Leiden University for one afternoon. Part of their programme was to study an experimental text on human aggression.

Materials

Experimental Text. An experimental text on aggression was constructed. The text consisted of 10 chapters, all of which were presented with a small introduction. Two types of chapters were introduced. Chapters 1 and 2 were hypertexts: Students were free to choose theory and example paragraphs within a chapter. At least four paragraphs had to be read. Chapters 3 and 4 were fixed-order chapters with four theory paragraphs, all of which had to be read by the students. Chapters 5 and 6 were fixed-order chapters with four example paragraphs, all of which had to be read by the students. Chapters 7, 8, 9 and 10 were hypertexts with free choice of theory and example paragraphs with a minimum of four paragraphs to be read. Each chapter covered four subjects. The total number of words was 12,163 on 22 pages. The average number of words per paragraph was 171.
Posttest. The number of participants who participated in the test ($n = 23$) was limited. The reason is that the students were kindly requested to fill out the test at home through an Internet connection. An €10 book cheque was assigned at random among the participants.

The posttest on aggression consisted of 30 questions, 3 questions per chapter. The number of questions was reduced after running a reliability analysis. Decisions to include or not to include a particular item were made on the basis of an acceptable alpha on the one hand, and an attempt not to lose too many questions per chapter on the other. The resulting alpha was .53.

Learning Environment. The learning environment was developed in Macromedia Authorware. This application presented the text on a computer screen, together with appropriate buttons to navigate through the hypertext. The student was first presented with an introduction to the chapter in question. Then, by clicking on the "next" button, the student entered a new page in which he or she had to choose between a theory and an example paragraph. In case a theory paragraph was chosen for a start, after reading the paragraph the student proceeded by clicking on either "next" (the next theory paragraph) or "example", to switch to an example paragraph. In case an example paragraph was chosen for a start, after reading the paragraph the student proceeded by clicking on either "next" (the next example paragraph) or "theory", to switch to a theory paragraph. Immediately after the student had finished reading the experimental text, the application presented the posttest. All reading times per paragraph were recorded, together with all choices the student made and the posttest results.

Learning Styles Inventory. The Inventory of Learning Styles (Vermunt, 1992) consisted of statements about study situations. A learning style is "a coherent whole (...) of learning activities that students develop naturally." The student had to indicate on a five-point scale to what extent the statement would apply to him. The dimension extends from ("I (virtually) never do this") to "I (virtually) always do this". The ILS consists of 120 items, of which the subscale Concrete Elaboration (CE) is a subscale, consisting of 5 statements to which 5 filler statements were added (see appendix).

Data analysis

The independent variable was Learning Style (High and Low CE). The within-subjects variables were Chapter Type (Hypertext, Fixed Text), and Chapter Number (1 to 10). The dependent variables were paragraph visits per chapter and posttest scores. Paragraphs that were on the screen for less than 10 seconds were assumed to be browsed by the students, not read. So, these paragraphs were supposed to be not visited. ANOVAs were executed on the data to uncover within-subjects and the between- subjects effects.

Results

Number of paragraph visits in fixed chapters

The difference between number of paragraphs read in the two theory chapters (M = 3.63, SD = .87) and the two example chapters (M = 2.91, SD = 1.48) turned out significant (F (1, 102) = 36.19, p < .01). Table 1 provides the details. More theory paragraphs were read than example paragraphs. The data showed that more browsing was observed in the example chapters than in the theory chapters. There was no significant effect of Learning Style, neither was the interaction between Chapter Type and Learning Style significant.

Table 1. Number of Theory and Example Paragraphs Read per Fixed Chapter and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low n = 46		High n = 58	
	M	*SD*	*M*	*SD*
Chapter 3: Four Theory Paragraphs	3.85	.56	3.71	.79
Chapter 4: Four Theory Paragraphs	3.72	.89	3.31	1.42
Chapter 5: Four Example Paragraphs	3.39	1.29	2.76	1.68
Chapter 6: Four Example Paragraphs	3.04	1.59	2.59	1.72

Within each pair of chapters (the two theory chapters and the two example chapters) the first chapter was read more completely than the second chapter (F (1, 102) = 11.41, p < .01). The average of paragraph visits of Chapters 3 and 5 was 3.40 (*SD* = .96) and of Chapters 4 and 6 3.14 (*SD* = 1.27).

Number of paragraph visits in hypertext chapters

Only hypertext chapters were included in this analysis. Chapters 9 and 10 were excluded from the analysis because of the low frequency of paragraph visits and the high between students variance. The number of example paragraphs and theory paragraphs read is shown in Table 2. The difference between number of paragraphs read in Chapters 1 and 2 on the one hand, and Chapters 7 and 8 on the other hand, turned out significant (F (1, 35) = 33.65, p < .01). Students read more paragraphs in Chapters 1 and 2 (M = 2.51, *SD* = 1.72) than in Chapters 7 and 8 (M = 1.44, *SD* = 1.79). Furthermore, an effect of sequence was found within the first two hypertext chapters (Chapter 1: M = 2.56, *SD* = 1.63; Chapter 2: M = 2.36, *SD* = 1.81) and last two hypertext chapters (Chapter 7: M = 1.68, *SD* = 1.88; Chapter 8: M = 1.20, *SD* = 1.70). This sequence effect was significant (F (1, 35) = 21.11, p < .01). Students read more paragraphs from the first than from the second chapter within each pair of hypertext chapters.

Table 2. Number of Theory and Example Paragraphs Read per Hypertext Chapter and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low n = 19		High n = 18	
	M	*SD*	*M*	*SD*
Chapter 1: Four Theory Paragraphs	2.84	1.61	3.00	1.50
Chapter 1: Four Example Paragraphs	2.21	1.78	2.56	1.69
Chapter 2: Four Theory Paragraphs	2.53	1.74	2.76	1.71
Chapter 2: Four Example Paragraphs	2.16	1.86	2.06	2.01
Chapter 7: Four Theory Paragraphs	1.63	1.83	1.94	1.86
Chapter 7: Four Example Paragraphs	2.11	2.05	1.00	1.68
Chapter 8: Four Theory Paragraphs	1.00	1.67	1.61	1.82
Chapter 8: Four Example Paragraphs	1.37	1.89	.83	1.38

In order to obtain a more accurate picture of the attention high CE and low CE students paid to example paragraphs and theory paragraphs we focused on the proportion of theory paragraphs per chapter. A repeated measures analysis revealed a marginally significant effect of Learning Style (F (1, 67) = 3.58, p = .063). High CE students tend to read a higher proportion of theory paragraphs (M = .61, SD = .06) than low CE students (M = .45, SD = .06). Moreover, an interaction effect between Concrete Elaboration and Chapter Sequence (F (1, 39 = 6.31, p < .05) showed up. During the first two chapters, high CE students (M = .54, SD = .35) and low CE students (M = .47, SD = .37) did not show much difference in proportion of theory paragraphs read. During Chapters 7 and 8 high CE students (M = .68, SD = .40) read proportionally more theory paragraphs than did low CE students (M = .42, SD = .45) who devoted most of their attention to example paragraphs. Table 3 presents the data and Figure 1 shows the interaction.

Table 3. Proportion of Theory Paragraphs Read per Hypertext Chapter and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low n = 34		High n = 35	
	M	*SD*	*M*	*SD*
Chapter 1	.48	.38	.56	.33
Chapter 2	.45	.40	.52	.36
Chapter 7	.37	.46	.68	.40
Chapter 8	.47	.47	.67	.42

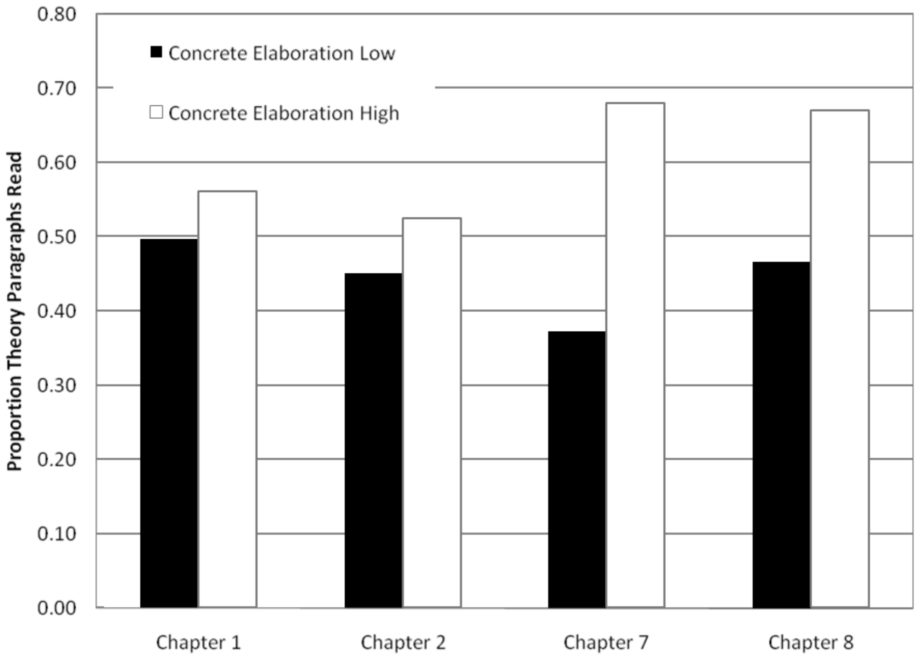

Figure 1. Interaction between Learning Style and Chapter Order on Proportion of Theory Paragraphs Read per Chapter.

Learning outcomes

Table 4 shows the posttest scores for all chapters. Scores are presented as proportions, that is, number of correct answers divided by number of questions per chapter. A repeated measures analysis was executed on the hypertext chapters (1, 2, 7, and 8). A comparison was made between Chapters 1 and 2 taken together and Chapters 7 and 8 taken together. The difference between posttest scores on Chapters 1 and 2 (M = .57, SD = .18) and posttest scores on Chapters 7 and 8 (M = .77, SD = .19) turned out significant (F (1, 21) = 19.83, p < .01). The students performed better on Chapters 7 and 8 than on Chapters1 and 2.

Table 4. Posttest Scores per Chapter and Level of Concrete Elaboration.

	Concrete Elaboration			
	Low n = 12		High n = 11	
	M	*SD*	*M*	*SD*
Chapter 1	.58	.21	.82	.17
Chapter 2	.33	.28	.55	.17
Chapter 3	.58	.36	.77	.26
Chapter 4	.58	.25	.67	.37
Chapter 5	.67	.25	.64	.35
Chapter 6	.67	.49	.82	.40
Chapter 7	.75	.15	.76	.22
Chapter 8	.78	.30	.79	.27
Chapter 9	.59	.38	.55	.42
Chapter 10	.33	.33	.39	.29

Low CE students performed worse on questions on Chapters 1 and 2 than high CE students did. There was no difference between high CE and low CE students in performance on Chapters 7 and 8. The interaction between Chapter Sequence and Learning Style turned out significant (F (1, 21) = 5.81, p < .05). The big difference in posttest scores on Chapters 1 and 2 between low and high CE students disappeared when the scores on Chapters 7 and 8 were compared. Figure 2 displays the interaction.

Posttest scores on the fixed chapters (Chapters 3 and 4: Theory paragraphs; Chapters 5 and 6: Example paragraphs) did not differ for high and low CE students, despite the apparent poor performance of low CE students on the two theory chapters with a fixed sequence of paragraphs. Neither was the difference between two chapter types significant.

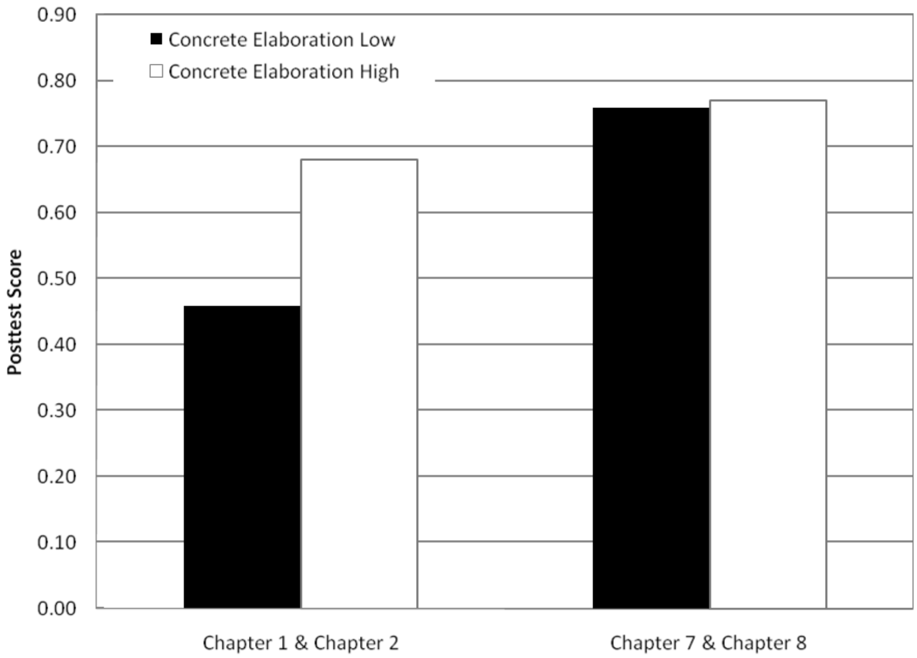

Figure 2. *Interaction between Learning Style and Chapter Order on Posttest Scores.*

Discussion

The most interesting finding of this Experiment was that both high and low CE students used the theory paragraphs of the first two hypertext chapters as a point of departure for studying the text. Both groups read more theory paragraphs than example paragraphs of these two chapters. However, when they arrived at the seventh chapter of the text, this picture changed. After becoming more familiar with the content of the text, and after having discovered that the theory paragraphs and the example paragraphs were complimentary in the sense that they both explained the same “deep structure” (Kintsch & Van Dijk, 1978), high and low CE students developed different reading strategies: High CE students stayed with the theory paragraphs whereas low CE students used example paragraphs as point of departure to explore the text.

Theory chapters did not produce better performance on the comprehension test than example chapters, despite the fact that theory chapters were better read than example chapters. Although posttest scores per chapter varied considerably, there was no clear pattern favouring the fixed chapters over the hypertext chapters. Apparently, text content was a more powerful variable than text format.

As far as the differences between high and low CE students were concerned, the comprehension scores mirrored the reading strategy data. As students started to study the text departing from the theory paragraphs, high CE students already exerted their preferred reading strategy. Consequently, they performed better on the test questions about the first two chapters than low CE students. However, after a while, both groups of students had discovered that the text accommodated their preferred reading strategy, with a focus on theory paragraphs for the high CE students and a focus on example paragraphs for the low CE students. As a consequence, comprehension performance on test questions about the seventh and eighth chapters were at the same level for both groups of students. Because the text allowed for both a theory-oriented and an example-oriented reading strategy, students arrived at the same posttest performance as soon as they had developed a reading strategy which matched their learning style.

The results of this experiment shed a new light on the induction versus deduction and the adaptation versus accumulation controversy. Jonker, Beishuizen, and Veenman (submitted) concluded that the adaptation versus accumulation received more empirical support than the induction versus deduction explanation of Vermunt's (1992, 1998) learning style of concrete elaboration. However, in a learning environment in which readers could fully deploy their preferred reading strategies low CE students developed a clear preference for studying example paragraphs. So, the data suggest that the prevailing habit of many teachers and students of focussing on theories and not on examples in study texts seems beneficial to high CE students but detrimental to low CE students. It is similar to the ancient habit of forcing all students to write with their right hand, irrespective of their right or left hand preference. So, low CE students may not follow a rather indifferent accumulation strategy but may be forced by the prevailing educational culture to focus on theories instead of examples.

The results of this experiment were obtained by asking students to study a text with fixed sequence of chapters. So, the data on reading strategies and comprehension performance may have been contaminated by text content. Therefore, we decided to run a second experiment in which freedom of choice of chapters was added to freedom of choice of paragraphs within chapters.

Experiment 2. Studying an Experimental Hypertext with Free Choice of Chapters, Theory Paragraphs and Example Paragraphs

Experiment 2 was aimed at addressing the same research questions as Experiment 1. However, an extra condition was introduced: Freedom of choice of chapters to be studied. As explained in the discussion section of Experiment 1, this extra condition was introduced to control the effects of chapter content. The findings of Experiment 1 might have been contaminated by the fact that, for instance, the content of the first two chapters caused a differential effect on high and low CE students: Low CE students might have experienced more trouble understanding the chapter because of its content than high CE students.

In this second experiment, upper secondary school students were presented with a text on human aggression. The text consisted of ten chapters. One version of the text presented the chapters in a predetermined order and allowed students to choose paragraphs within a chapter according to their own preference. The second version allowed students to choose freely both chapters and paragraphs within chapters. After studying the text students completed a comprehension test. In accordance with the results of Experiment 1, we expected that both high and low CE students start with theory paragraphs. However, in the course of studying the text, high CE students were expected to maintain their preference for theory paragraphs, whereas low CE students were expected to gradually shift their attention to example paragraphs. We expected that students would perform equally on questions about theory paragraphs and on questions about example paragraphs. High CE students were expected to perform better than low CE students on comprehension questions about the initial chapters studied. However, gradually both groups of students were supposed to arrive at the same level of performance on the posttest. Ordering of the chapters (either linear or nonlinear) was not expected to affect performance on the comprehension test.

Method

Participants

Students were recruited from two different schools. 37 students came from a school from the western part of the Netherlands near the city of Leiden, 30 students came from a school in Amsterdam. All students voluntarily agreed to participate in the experiment. By agreeing to participate they also accepted the terms and conditions of the experiment. All students received a small reward for participating in the experiment. From the total of 67 students (26 male, 41 female) 34 were assigned to the linear text and 33 to the nonlinear (landscape) version. Mean age was 16.83 (*SD* = 1.43).

Materials

Inventory of Learning Styles. The ILS (Vermunt, 1992, 1998) comprises of 20 scales encompassing 120 items. In this research, only the first 55 items were administered to the students. Scores on Concrete Elaboration subscale were dichotomized on the median (median = 14).

Experimental Text. The content of the text was aggression. The text consisted of 10 chapters. Chapters 1, 2, 7, 8, 9, 10 consisted of an introductory text followed by four example and four theory paragraphs. Chapters 3 and 4 consisted of four theory paragraphs and Chapters 5 and 6 consisted of four example paragraphs.

Learning Environment. The text was presented in, and the participants were assigned to, two different hypertext versions: A linear chapter order version and a nonlinear chapter order version. The linear chapter order version was identical to the interface created in Experiment 1. The nonlinear chapter order version deviated in that the student was allowed to choose between chapters by clicking on one of 10 buttons representing the chapters of the text. The buttons were arranged in an ellipse, preventing the students from studying in a particular order. Chapters which had been chosen were marked with a red bullet. After having chosen a chapter, the student read the introductory paragraph and decided to continue within the chapter or to choose a new chapter. Within a chapter the student could choose between the four topics of the chapter by clicking on one of the four buttons representing the topics. Next, the student could choose between a theory paragraph and an example paragraph.

Posttest. The posttest consisted of 30 multiple choice questions, three questions per chapter. A reliability analysis revealed that six questions had negative item-rest correlations. These items were removed from the test. After removal of the items the test had a Cronbach's alpha reliability coefficient of .43.

Procedure

The experiment took place in two sessions. In session 1, the participants were instructed and were asked to fill out their informed consent forms in which they signed for the conditions under which the research would take place. A case description was assigned to all of them. The case description provided the student with the perspective from which they had to study the experimental text on aggression. Next, they received 20 minutes to study the text, in either the linear chapter or the nonlinear chapter order version. Finally, they completed the Inventory of Learning Styles.

During the second session, the posttest was administered, on which the students were allowed to spend 20 minutes at most. Time between the sessions was 1 day for one school and 2 days for the other.

Results

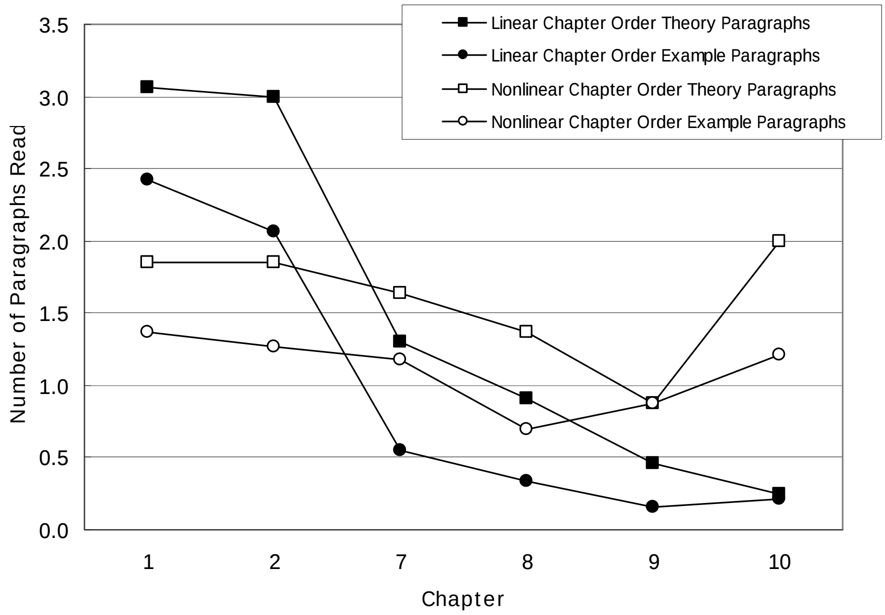

Figure 3. *Number of Paragraphs Read per Chapter and Type of Paragraph.*

Number of paragraphs visits per chapter

The number of paragraphs read differed with chapter (F (5, 60) = 28.23 p < .01). A linear trend was found for Chapter Order (F (1, 64) = 145.77, p < .01). This means that the number of paragraphs read declined with chapter progression. Figure 3 shows the data. In addition to that, an effect was found of Hypertext Version (Linear Chapter Order versus Nonlinear Chapter Order) (F (5, 60) = 30.68, p < .01). The average number of paragraphs read per chapter turned out higher for the linear version (theory paragraphs: M = 1.60, SD = .14; example paragraphs: M = 1.10, SD = .15) than for the nonlinear version (theory paragraphs: M = 1.49, SD = .14; example paragraphs: M = .95, SD = .15). Also the interaction between Chapter Order and Hypertext Version displayed a significant linear effect (F (1, 64) = 111.50, p < 0.01). For the Linear Chapter Order, the number of paragraphs read strongly declines, whilst for the Nonlinear Chapter Order that was not the case. Figure 3 shows the interaction. It is clear that this interaction is the result of an artifact. For the Linear Chapter Order, the sequence of reading coincided with the chapter order, whereas for the Nonlinear Chapter Order the sequence of reading was flexible and varied from participant to participant. Therefore, for each individual student we reassembled the chapter ordering data based on the actual reading sequence of the student. This was done for the first seven chapters that had been read, because from the 8th chapter in time sequence onwards a sharp decline was observed in terms of number of paragraphs read. We called this new independent variable Chapter Reading Sequence. An ANOVA showed an effect for Chapter Reading Sequence (F (6, 24) = 4.54, p < 0.01). The linear trend for Chapter Reading Sequence turned out significant (F (1, 29) = 30.45, p < 0.01). Paragraph Type proved to be significant (F (1, 29) = 21.77, p < 0.01). More theory paragraphs (M = 2.06, SD = .08) than example paragraphs (M = 1.04, SD = .09) were read. A significant interaction between Chapter Reading Sequence and Paragraph Type (F (6, 24) = 2.62, p < 0.05) with a significant linear effect (F (1, 29) = 7.37, p < 0.05) showed up. Interaction between Paragraph Type and Level of Concrete Elaboration was marginally significant (F (1, 29) = 3.90, p = 0.058). The difference between the number of theory paragraphs read and example paragraphs read in the initial chapters tended to be larger for low CE students than for high CE students. At the final chapters that difference was much smaller and on Chapter 7 even reversed for the low CE students. See Figure 4.

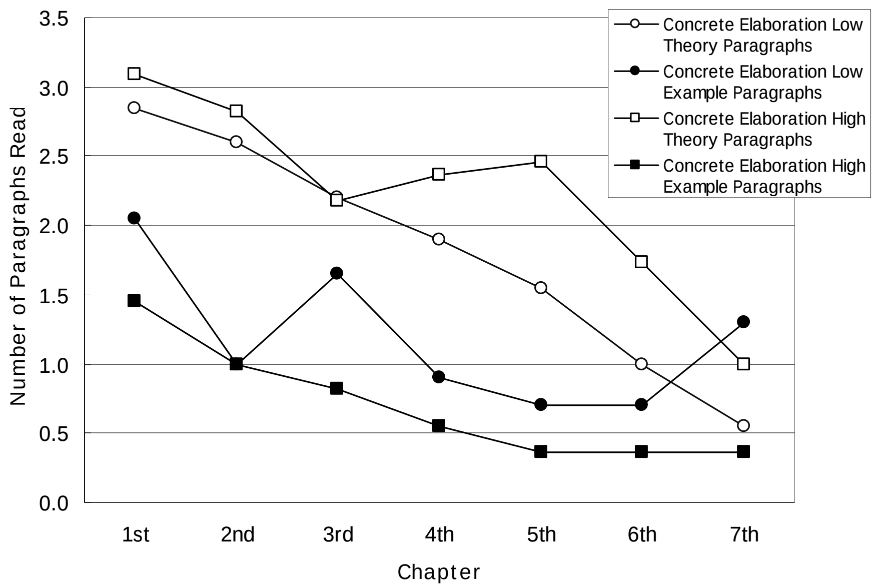

Figure 4. Interaction between Chapter Reading Sequence, Type of Paragraph and Level of Concrete Elaboration.

In order to obtain a more accurate picture of the attention high CE and low CE students paid to example paragraphs and theory paragraphs we focused on the proportion of theory paragraphs per chapter. A repeated measures analysis revealed a significant effect of Chapter Reading Sequence (F (6, 56) = 20.48, p <.01) and a significant effect of Hypertext Version (F (1, 61) = 5.61, p < .05). Moreover, the interaction between Chapter Reading Sequence and Hypertext Version was significant (F (6, 56) = 11.06, p < .01). As Figure 5 shows, a gradual decline of the proportion of theory paragraphs read showed up in the course of reading the study text, but this decline was more marked for reading the linearly ordered chapters than for the hypertext version in which students could determine the order of reading chapters themselves. Overall, students read a higher proportion of theory paragraphs in the Nonlinear Chapter Order version (M = .61, SD = .24) than in the Linear Chapter Order version (M = .50, SD = .29). There was no effect of Learning Style (F < 1) but the interaction between Chapter Reading Sequence and Level of Concrete Elaboration was significant (F (1, 61) = 5.94, p < .05). As Figure 5 shows, in the nonlinear chapter ordering condition high CE students read a high proportion of theory paragraphs. Actually, they maintained a relatively strong preference for theory paragraphs throughout reading the first six chapters, whereas for low CE students the preference for theory paragraphs gradually declined (see Figure 5). This confirmed the findings of Experiment 1, but only for the nonlinear chapter order condition.

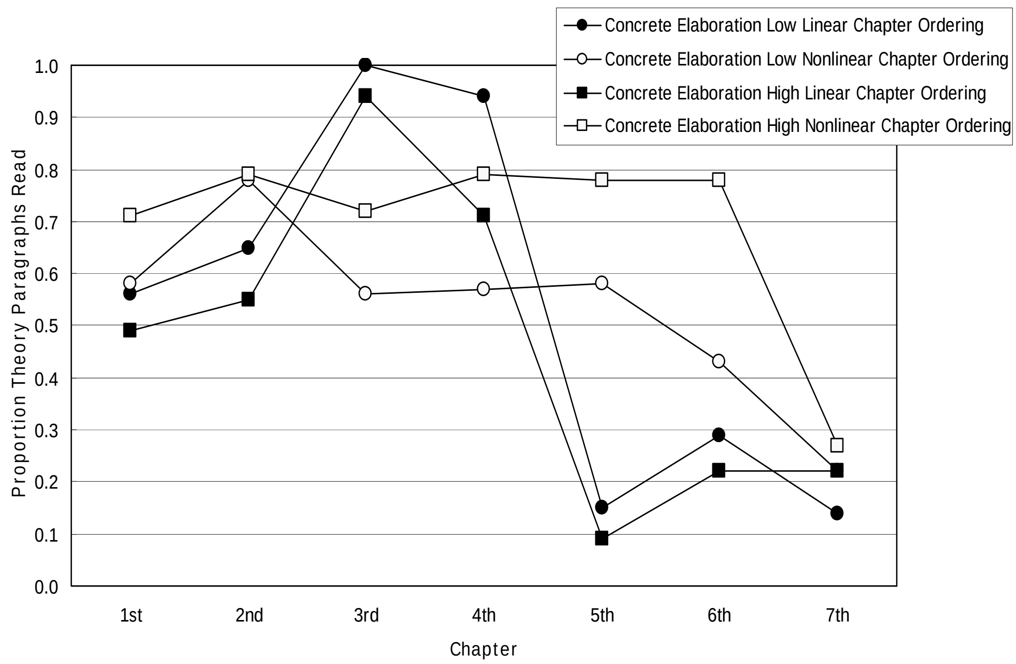

Figure 5. Interaction between Level of Concrete Elaboration and Hypertext Version.

Posttest scores

The lack of content effect of theory chapters versus example chapters, which was found in Experiment 1, was disconfirmed in this experiment. In the Linear Chapter Ordering condition students performed worse on questions about the two theory chapters (M = .53, SD = .18) than questions about example chapters (M = .68, SD =

.22). This difference was significant (*F* (1, 29) = 10.59, *p* <.01). There was no effect of Level of Concrete Elaboration (*F* < 1), and also no interaction effect (*F* < 1). To analyse effects of Chapter Reading Sequence, Hypertext Version, and Level of Concrete Elaboration on the posttest performance, scores of the first seven chapters which were read by the students were included in an Analysis of Variance. There was a main effect of Chapter Order Sequence (*F* (6, 47) = 15.13, *p* < .01). Also the linear effect turned out significant (*F* (1, 52) = 23.88, *p* < .01). This means that the scores declined linearly per chapter read. The data are shown in Table 5. The posttest scores reflected the number of paragraphs read per chapter (see Figure 4). Although the main effect of Hypertext Version was not significant, there was a significant interaction between Chapter Reading Sequence and Hypertext Version (*F* (6, 47) = 6.75, *p* < .01). The linearly declining posttest performance effect was different for students reading according to a linear chapter ordering or a nonlinear ordering.

Table 5. Posttest Scores per Chapter in the Actual Reading Sequence. Only the First Seven Chapters have been Included.

	Linear Chapter Ordering		Nonlinear Chapter Ordering	
Chapter Reading Sequence	*M*	*SD*	*M*	*SD*
1st Chapter	.53	.36	.66	.35
2nd Chapter	.90	.23	.58	.31
3rd Chapter	.57	.26	.46	.30
4th Chapter	.47	.30	.64	.38
5th Chapter	.53	.38	.60	.36
6th Chapter	.35	.44	.39	.35
7th Chapter	.22	.33	.26	.37

Table 5 shows that these slightly deviating curves are difficult to disentangle. Part of the differences may have been caused by the relatively easy Chapter 2, which encountered all students in the Linear Hypertext Version as their second chapter. The data suggest that in the Nonlinear Hypertext version students stayed longer at a higher level of performance.

There was no main effect of Level of Concrete Elaboration (*F* < 1) and the interaction between Chapter Reading Sequence, Chapter Order and Level of Concrete Elaboration was not significant (*F* (6, 47) = 1.99, p = .09). Table 5 shows the posttest scores for the Linear Chapter Order condition and the Nonlinear Chapter

Order Condition. Within the subgroup of students working with the nonlinear chapter order version, the interaction between Chapter Order and Level of Concrete Elaboration was significant (F (6, 19) = 3.64, p < .05). Differences in posttest performance between high and low CE students were visible among the scores on the final chapters, but not on the initial chapters. The biggest differences showed up when comparing the posttest scores on Chapters 6 and 7. Chapter 7 is a special case because high CE students read a small number of paragraphs.

Discussion

More theory paragraphs than example paragraphs were read. The shrinking difference between number of theory paragraphs and number of example paragraphs read reflected the fact that, in the course of reading, students studied less and less theory paragraphs whereas the number of example paragraphs read remained small but constant.

The difference between the number of theory paragraphs read and example paragraphs read was in the initial chapters larger for low CE students than for high CE students. Half of the students started with a theoretical introduction on the topic of the chapter. As Figure 4 shows, during reading the final chapters the difference between number of theory paragraphs and number of example paragraphs is much smaller and even reversed for the low CE students: On average, they read more example chapters than theory chapters of the 7^{th} chapter. So, there was a gradual change of reading behaviour among the low CE students, but it was not as clear as in the first experiment. The cognitive load of choosing between chapters may have suppressed the differential effect of high and low concrete elaboration. It appears that in the current experiment the articulation of learning style differences took more time than in the previous experiment.

Although differences between chapters with only theory paragraphs and only example paragraphs were not significant in the first experiment, the data of this experiment do confirm that students performed better on questions about example chapters than on questions about theory chapters, irrespective of their level of concrete elaboration.

Although the main effect of Hypertext Version was not significant, there was a significant interaction between Chapter Reading Sequence and Hypertext Version. The linearly declining posttest performance trend was different for students reading according to a linear chapter ordering or a nonlinear ordering. Part of the differences may have been caused by the relatively easy Chapter 2, which encountered all students in the Linear Hypertext version as their second chapter. The data suggest that in the Nonlinear Hypertext version students stayed longer at a higher level of performance, except for Chapter 7.

We expected that high CE students would perform better than low CE students on comprehension questions about the initial chapters studied. However, gradually both groups of students were expected to arrive at the same level of performance on the posttest. This sequence effect, which was found in the first experiment of this chapter, was definitely not confirmed in this second experiment. Only the last chapters read in the Nonlinear Chapter Ordering condition do reflect some learning style specific differences. On the sixth chapter high CE students read a higher proportion of theory paragraphs than low CE students and also perform better on the posttest than low CE students. The reverse was shown on the seventh chapter. Here low CE students read a higher proportion of example chapters and performed better than high CE students.

General Discussion

The experiments in this study show that students have to learn to grasp the opportunities for cognitive flexibility which a hypertext offers. When free to choose, students tend to prefer theory chapters over example chapters, and, within chapters, theory explanations over examples. This preference may reflect either the educational culture, with its emphasis on the value of theories instead of examples to convey a body of knowledge, or the fact that students in general consider theories as more difficult and, consequently, more valuable. So the blessings of cognitive flexibility may not be so natural or obvious to upper secondary school students.

This general preference for theoretical explanations is in line with the learning style of high CE students. They tend to take theory descriptions as a point of departure and use examples in the text and their own experience to give concrete form to what they read (Beishuizen et al., 2003; Vermunt, 1992; Jonker, Beishuizen & Veenman, submitted).

But what about the low CE students? Did they develop their own reading strategy? The first experiment showed a clear development towards an example oriented reading strategy for low CE students. Apparently, low CE students had to break away from the dominant theory orientation of studying expository texts. In the course of studying the text they gradually learned to develop a strategy with more emphasis on using examples in the text to create an internal representation. This trend was partially confirmed in the second experiment. Again, an orientation on theory explanations was predominant, both among high CE and low CE students. In the Linear Chapter Ordering version, this tendency declined for both groups in the course of the reading session to the same extent. In the Nonlinear Chapter Ordering version, low CE students have small preference for theory explanations until the sixth chapter when example paragraphs take the lead. Perhaps, the choice of chapters enhanced the cognitive load of the task, preventing low CE students to choose more openly for their preference of examples in the text.

What are the implications of the findings for the choice between the induction versus deduction explanation versus the adaptation versus accumulation explanation of Vermunt's (1992; 1998) concept of Concrete Elaboration? It appears that the tendency to prefer the adaptation versus accumulation explanation which resulted from Jonker, Beishuizen, and Veenman's (submitted) study needs to be qualified. Both experiments in this chapter suggest that low CE students are more example oriented than theory oriented which supports the induction versus deduction point of view. What we have learned from this study refers to the fact that low CE students appear not to be in line with the predominant theory oriented character of our educational system. Low CE students have to actively break away from this orientation in order to develop their own reading strategy, in accordance with their learning style. A hypertext learning environment offers appropriate conditions to develop cognitive flexibility (Spiro et al., 1987; Spiro & Jehng, 1990; Jacobson & Spiro, 1995). Such an environment imposes a considerable amount of cognitive load on the reader, who may need more time to develop an efficient and effective reading strategy than in a traditional linear reading environment. However, if there is room for such development, then students with various inductive and deductive learning styles may eventually be able to grasp the opportunities and successfully complete their journey through the landscape of the ill structured domain.

References

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology*, 73(3), 291-316.

Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology* (72), 279-297.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, 11, 717 - 726.

Chi, M. T. H., & VanLehn, K. A. (1991). The Content of Physics Self-Explanations. *Journal of the Learning Sciences*, 1(1), 69-105.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, 12(4), 301 - 333.

Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). Understanding an expository text – a process analysis.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, 95(2), 163-182.

Kintsch, W., & van Dijk, T. (1978). Toward a model of text comprehension and production. *Psychological Review*, 85(5), 363-394.

Marton, F., & Saljö, R. (1997). Approaches to learning. In F. Marton, D. Hounsell & N. Entwistle (Eds.), *The experience of learning: Implications for teaching and studying in higher education* (2nd ed., pp. 39-58). Edinburgh, Great Britain: Scottish Academic Press.

McKnight, C., Dillon, A., & Richardson, J. (Eds.). (1993). *Hypertext; a psychological perspective*. Chichester, England: Ellis Horwood Ltd.

Nelson, T. H. (1967). Getting it out of our system. In G. Schecter (Ed.), *Information retrieval: A critical review* (pp. 191 - 211). Washington, DC: Thompson Books.

Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In D. Nix & R. J. Spiro (Eds.), Cognition, education and multimedia exploring ideas in high technology (pp. 163 - 205): Hillsdale, NJ: Erlbaum.

Trumbull, D., Gay, G., & Mazur, J. (1992). Students' actual and perceived use of navigational and guidance tools in a hypermedia program. *Journal of Research on Computing in Education*, 23(3), 315-328.

Vermunt, J. D. H. M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken*. Swets & Zeitlinger, Amsterdam.

Vermunt, J. D. H. M. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology* (68), 149-171.

Chapter 5 Concrete Elaboration during Knowledge Acquisition by Studying and Experimenting[4]

Abstract

Reading can have many different purposes. The purpose we examined in this study was preparing for designing and conducting experiments. We explored the role of concrete elaboration, a learning style defined by Vermunt (1992), in the cognitive tasks of studying a text and, subsequently, conducting experiments in order to understand the working of human memory. Upper secondary school students studied a text on human memory in order to prepare for conducting an experiment in a simulation environment on human memory. The students were interviewed three times about their understanding of the theoretical model embedded in the simulation environment. Together with process data, representing the way students studied the text on human memory, and conducted experiments in the simulation environment, these three theory interviews were used to compare two alternative explanations for the nature of the cognitive processes behind the concrete elaboration learning style. It was found that, apart from prior knowledge, time invested in reading theory paragraphs, carefully manipulating one variable at a time, and seriously considering individual experiments, all predict the performance on the final interview; whereas time invested in reading examples does not. As far as experimenting behaviour is concerned, no differences were found with regard to either preference or learning style. Finally, we concluded that of the two competing explanations, deduction versus induction is accommodating our data better than adaptation versus accumulation, both on the broader task level and on the local reading task.

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[4] Jonker, H.G., Beishuizen, J.J., & Veenman, M.V.J. (submitted). *Studying for Experimenting - the Value of Theory Descriptions and Examples.*

Introduction

Reading a study text may serve various purposes (Brewer & Lichtenstein, 1982). One obvious objective is to prepare for a comprehension test. Students read study texts in order to pass an examination. Preparing for an open-end questions test elicits other study behaviour than preparing for a multiple choice test (Beishuizen & Stoutjesdijk, 1999). But how do students study a text as a preparation for a productive task like operating a computer or conducting an experiment? Reading manuals in order to solve a problem is a well-studied cognitive task (e.g., Wiese, Sauer, & Rüttinger, 2004). People tend to be very goal oriented in such a task and actively search for a particular explanation. Reading in order to conduct experiments may be comparable with reading a manual. The reading task is tuned to the consequential task of running experiments. Readers need to know just enough in order to be able to formulate predictions to be tested in subsequent experiments. Under these circumstances, the reader's learning style may affect the choice of an appropriate reading strategy.

Vermunt (1992) included in his Inventory of Learning Styles a scale named Concrete Elaboration, which assesses the extent to which students have the habit of giving concrete form to what they read. Vermunt (1992) defined Concrete Elaboration as "relating course contents to concrete things that are already known, such as personal experiences, concrete visual images, events in daily reality, practical applications" (p. 650). Students with a high score use the course content to generate concrete examples of everyday practice out of their personal experience. What is the nature of the Concrete Elaboration learning style in terms of information processing? Two interpretations are possible: (1) The induction versus deduction interpretation, and (4) the adaptation versus accumulation interpretation.

According to the induction versus deduction interpretation (Beishuizen et al., 2003), readers use either the abstract concepts or the concrete examples in a study text to understand the text. According to the deductive approach readers use the abstract concepts in the text to activate episodes of personal experience in their own episodic memory. Readers use their own experience to understand what an abstract concept means. The opposite approach is inductive. According to this strategy, readers use the examples in the text to activate concepts is their semantic memory. So, they focus on the concrete parts in the text to create an internal representation of the meaning of the text.

Students with a high score on Vermunt's Concrete Elaboration scale obviously adopt a deductive approach. But what about a low score on the Concrete Elaboration scale and other types of study texts? Are students with a low score simply not used to relating course contents to episodes of personal experience or do they habitually work along the inductive approach, extracting the meaning of concepts and principles from examples in the text and from personal experience? To put it differently, does the concrete elaboration dimension juxtapose the habits of deductive versus inductive text comprehension?

According to the adaptation versus accumulation interpretation (Beishuizen et al., 2003) , some students adapt their own personal knowledge by activating relevant examples, and integrating the new conceptual information with their existing knowledge in order to arrive at a coherent representation. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many examples. Other students do not activate existing knowledge to the same extent and try to pay attention to as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

Students with a high score on Vermunt’s Concrete Elaboration scale may be more inclined to adapt their existing knowledge, whereas students with a low score do not operate strategically but merely try to accumulate as much knowledge as possible.

Inductive and deductive information processing strategies have been reported in the domain of solving physics problems. Chi and VanLehn (1991) showed that students, studying physics examples, generated two kinds of explanations. The first type of explanation was created by a deductive approach: Instantiating a main idea with information in the example statement. The second type of explanation was arrived at by way of an inductive approach: Generalisation and extension of the example statement. Klahr and Dunbar (1988) studied the way students explored what they called the “hypothesis space” and the “experiment space” in a simulation environment. Some students preferred to focus on the hypothesis space, which seems akin to the deductive approach, whereas other students ran many experiments and tried to induce knowledge from the outcomes of these experiments (de Jong & van Joolingen, 1998).

In this experiment, we tried to find support for either the induction versus deduction explanation or the adaptation versus accumulation explanation by asking students to conduct experiments on human memory after studying examples and theoretical accounts of the principles of the processes of learning and recollection to be studied in a simulation environment. For this experiment, the FILE environment, developed by Wilhelm (see Wilhelm, 2001; Wilhelm & Beishuizen, 2004; De Jong et al., 2005; Hulshof, Wilhelm, Beishuizen, & Van Rijn, 2005; Wilhelm, Beishuizen, & Van Rijn, 2005), was adapted. In a simple factorial design, the effect of five independent variables representing individual and task characteristics on one dependent variable, performance on a free recall task, was studied. Students received a nonlinear expository text with an introduction and five chapters in which the relationship between each of the five independent variables and the dependent variable was explained. Each chapter consisted of theory paragraphs and examples paragraphs. After reading the introduction, students completed a theory interview, in which they expressed their preliminary expectations about the relationships between independent and dependent variables, to be studied in the FILE environment. After this initial theory interview, students were encouraged to explore the on-line linear text, and conducted experiments in the FILE environment. Based on the conclusions they derived from the experiments carried out, they received for each independent variable either positive feedback or were referred back to a particular section of the text, in which information about the relationship between the relevant independent variable and the dependent variable was provided. The task ended when the student had explored all independent variables and, for each independent variable, had made at least two attempts to explain the relationship with the dependent variable. A final theory interview was taken, to confirm the student's conclusions about the relationships between independent and dependent variables. After finishing the task, students completed a comprehension test about the aspects of human memory investigated in the experiment. According to the adaptation versus accumulation explanation, students high on concrete elaboration were expected to focus on the theory paragraphs of the hypertext. Students were supposed to seek evidence confirming their initial ideas about the relationships between independent and dependent variables, as collected in the initial theory interview. Students low on concrete elaboration were expected to focus on the examples paragraphs of the expository text, and should study the text extensively, before engaging in the experimenting part of the task. According to the deductive versus inductive learning explanation, students low on concrete elaboration were expected to quickly start to experiment and would use feedback to further explore the examples in the text. Students high on concrete elaboration were expected to spend a lot of time studying the expository text before designing their first experiment.

Method

Participants

Seventy-six (47 males, 29 females) eleventh grade secondary school students (mean age = 16.5; *SD* = .68) from three schools participated in the experiment. Thirty-two students came from two secondary schools in the urban area of Amsterdam and the remaining 44 students came from a secondary school in the city of Leiden. The three schools were invited to join the experiment because of long-standing relationships between the schools and the research institute. The participating students received a remuneration of €10 for their efforts that were expected to last for 75 to 90 minutes.

Materials

<u>Theoretical Model on Human Memory</u>. In both the simulation environment and the study text a theoretical model on human memory was embedded, which had to be discovered by the students by studying the text and conducting experiments. The model is displayed in Figure 1. The model contains five independent variables and

one dependent variable and explains the behaviour of participants in a virtual experiment who have to freely recall as many words as possible from a short story that has been simultaneously presented in two modes: as written text and orally. The short story contains 14 target words which either represent the core of the story (the essential target words) or minor details which do not determine the course of the story (the fringe target words). Moreover, virtual participants are presented as being recruited from three age groups: Adolescents (≈ 15 years of age), middle-aged persons (≈ 50 years of age), and old persons (≈ 80 years of age). Participants may possess either no relevant prior knowledge, average prior knowledge, or expert prior knowledge about the short story to be remembered. The target words have three different positions in the text: the beginning part, the middle part or the end part of the text. During the learning session, the short story is simultaneously presented orally and in written form. The written text is presented either on paper or via a computer screen. The dependent variable is the number of words remembered during a free recall posttest, taken immediately after the learning session. The relationship between independent and dependent variables is as follows. Two variables, presentation format and prior knowledge, have no influence on the dependent variable. Changing the value of these variables does not affect the value of the dependent variable. The variable position of a target word is related to the dependent variable; words placed at the beginning and the end of the text are better recalled than words from the middle part of the text. Two variables interact in their influence on the dependent variable. Age does not affect recall as long as the words are essential words. From the set of fringe words, adolescent and middle-aged participants remember more items than old participants. Discovering this interaction between the variables, age and meaning of target word, was the most difficult part of the task.

The model determined the outcomes of experiments conducted in the simulation environment. The model was also the basis for the study text on human memory which the students read before starting to experiment. The five chapters of the text explained the five independent variables of the model. However, it should be emphasized that the text did not necessarily describe what actually happened in the simulation environment. For instance, the chapter on prior knowledge explained that prior knowledge is an important factor in human memory processes. But in the simulation environment, because of the simple content of the short story to be remembered, prior knowledge was an irrelevant variable. The students had to actively verify whether or not prior knowledge was a determining factor in this particular experimental setting.

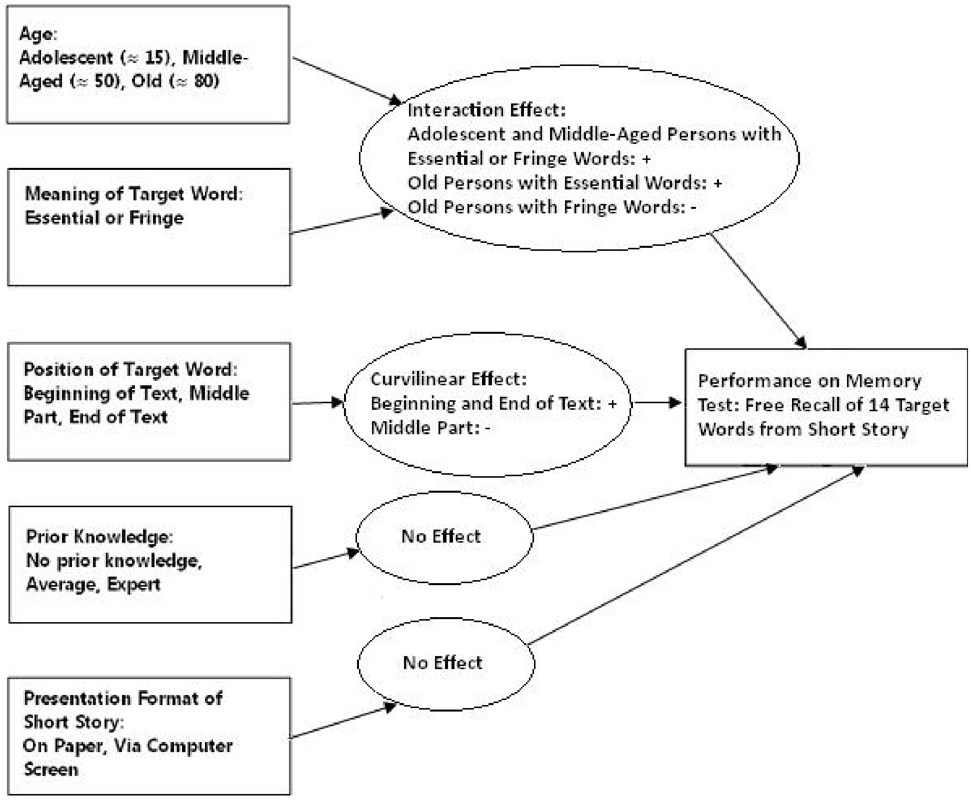

Figure 1. Theoretical Model Embedded in Study Text and Simulation Environment. Five Independent Variables Determine the Outcome of a Memory Test, in Which a Short Story has to be Remembered. Two Independent Variables are Irrelevant: Prior Knowledge and Presentation Format. Two Independent Variables Cause an Interaction Effect: Adolescent, Middle-Aged and Old Participants have the Same Recall of Essential Target Words, but Old Participants Fail on Fringe Target Words. One Variable has a Curvilinear Effect: Position of Target Word. Words in the Middle of the Story have a Lower Recall Frequency than Words at the Beginning and End of the Text.

Experimental Text. The experimental text consisted of five chapters that corresponded on a one to one basis with the independent variables in the theoretical model. Each of the five chapters consisted of three example paragraphs and three theory paragraphs. The content of the paragraphs was derived mainly from scientific literature.

Study & Experiment Environment (SEE). The Study & Experiment Environment (SEE) was developed by the first author and written in Macromedia Authorware. SEE was developed on the basis of Wilhelm's simulation environment for inductive learning FILE (see Wilhelm, 2001; Wilhelm & Beishuizen, 2004; De Jong et al., 2005; Hulshof, Wilhelm, Beishuizen, & Van Rijn, 2005; Wilhelm, Beishuizen, & Van Rijn, 2005).

SEE consisted of five modules:

1. On-line Concrete Elaboration Inventory
2. Theory Interview Module
3. Study Environment
4. Experiment Environment
5. Evaluation Questionnaire Module

<u>On-line Concrete Elaboration Inventory</u>. The 10 statements of the Concrete Elaboration subscale of Vermunt's (1992, 1998) Inventory of Learning Styles were presented one by one. The student marked his or her answer on a five-point scale. Students with a score below the median (13) were assigned to the low Concrete Elaboration (CE) subgroup. The remaining students were assigned to the high Concrete Elaboration (CE) subgroup.
<u>Theory Interview Module</u>. For each of the independent variables students were asked to write down what they expected the relationship with the dependent variable to be. For instance, they could write down "people remember more from a text on paper than from a text on a computer screen", or "old people recall less than adolescents". The format for the statements was completely open and students were free to write down as many statements as they liked. There was no support available in the form of a hypothesis scratchpad or a list of variables or operators to choose from. The only restriction was that students had to specify at least one expectation per independent variable. Examples were presented showing how to formulate a main effect hypothesis and or an interaction effect hypothesis. All statements were coded by two independent judges by matching the statement with a list of predefined statements specifying relationships between independent variables and dependent variable. The inter-rater reliability was .92. After that, the coded statements were assessed according to Wilhelm's (2001) rating scheme. Correct and complete statements like "recall scores are not influenced by presentation format" were awarded with 2 points. The interaction between the independent variables age and meaning of target word could be described in various statements which were awarded with 2 points, provided that a restriction specifying the value of the independent variable was added. A statement like "old people remember fewer fringe words than essential words" was awarded with 2 points" but "people remember as many essential words as fringe words" received 1 point, like all other correct but incomplete statements.
<u>Study Environment</u>. In the Study Environment students were free to choose which chapter to start with and which sequence of chapters to follow. After clicking a particular chapter a screen display appeared forcing the student to choose between example paragraphs and theory paragraphs. SEE did allow progress to the next

phase until at least one paragraph of all five chapters had been read. In addition to that the students were urged to continue reading chapters when they decided to leave a page before 80 seconds had been spent on the page. Reading times per paragraph were used to compile reading time per chapter, and further to compile example time and theory time per chapter.

<u>Experiment Environment</u>. In the Experiment Environment (see Figure 3), which was modelled after Wilhelm (2001; Wilhelm & Beishuizen, 2003), the students worked on a screen which was divided into three panels. The left hand panel showed the five independent variables with the two or three values of each variable represented by an icon which was actually a button to click on. By clicking on a white, square button with the name of the variable on it, the student returned to the relevant chapter in the Study Environment. The top panel contained a row of expected outcome values which could be chosen by clicking on one of them. The right hand panel displayed the results of a particular experiment as a row of values of the independent variables and the value of the corresponding dependent variable. The most recent experiment was always on top of the list.

Students were requested to conduct an experiment by specifying the value of each independent variable with a mouse-click on the appropriate icon in the left hand panel and by indicating a prediction of the expected value of the dependent variable in the top panel. After the student had confirmed the choices made, SEE provided the outcomes of the experiment in the top row of the results panel. A minimum of 15 experiments had to be conducted before concluding the experiment session. In the experiment depicted in Figure 3 (pp. 89) the student attempts to figure out what percentage of fringe words in the middle of the short story will be recalled by imaginary middle-aged participants with average prior knowledge who have read the text of the story on paper. The student has yet to indicate what the expected recall percentage will be: Either 20%, 30%, 40%, 50%, 60%, or 70%. The student might reason that middle-aged persons with average prior knowledge will end up with an average recall score of 50%.

The extend to which the participants made use of the Control of Variables Strategy (CVS) was measured by counting the number of independent variables changed with respect of the immediately preceding experiment. This number of changes was divided by the number of experiments minus one (the first experiment had no precedent) in order to arrive at the CVS score.

<u>Evaluation Questionnaire Module</u>. Ten evaluation statements were included for further validation of the students´ reading and experimenting behaviour. Students were asked to indicate on a five-point scale whether they had learned more from studying the text or from conducting experiments and whether the study text had been useful as a preparation for conducting experiments. Table 5 (pp. 96) contains the ten statements.

Procedure

The experimental procedure consisted of a general instruction, followed by a series of activities in SEE In the general instruction, students were invited to evaluate the Study and Experiment Environment (SEE) as an advanced tool for independent and research oriented learning. "[..] Assume you prepare for conducting research and you are provided with example texts and abstract texts. Which of these two types of text contribute most to a good preparation for the task afterwards, that is, doing experiments in an efficient way? You are going to address a memory test to 3 different age groups, and you will do that not in reality but via a computer simulation. [..] The memory test is a 131-word short story with 14 words in bold. These 14 words have to be reproduced by your imaginary participants immediately after reading. How is this memory score dependent on the 5 variables in Figure 1? Reading the chapters with attention is required for efficient experimenting afterwards. [..]"

After the general instruction seven activities are carried out in the Study and Experiment Environment (SEE): (1) Completing the On-line Concrete Elaboration Inventory, (2) expressing task specific prior knowledge in the first Theory Interview, (3) reading the text on human memory in the Study Environment, (4) specifying learning outcomes in the second Theory Interview, (5) conducting experiments in the Experiment Environment, (6) specifying learning outcomes in the third Theory Interview, (7) completing the Evaluation Questionnaire. The procedure is displayed in Figure 2.

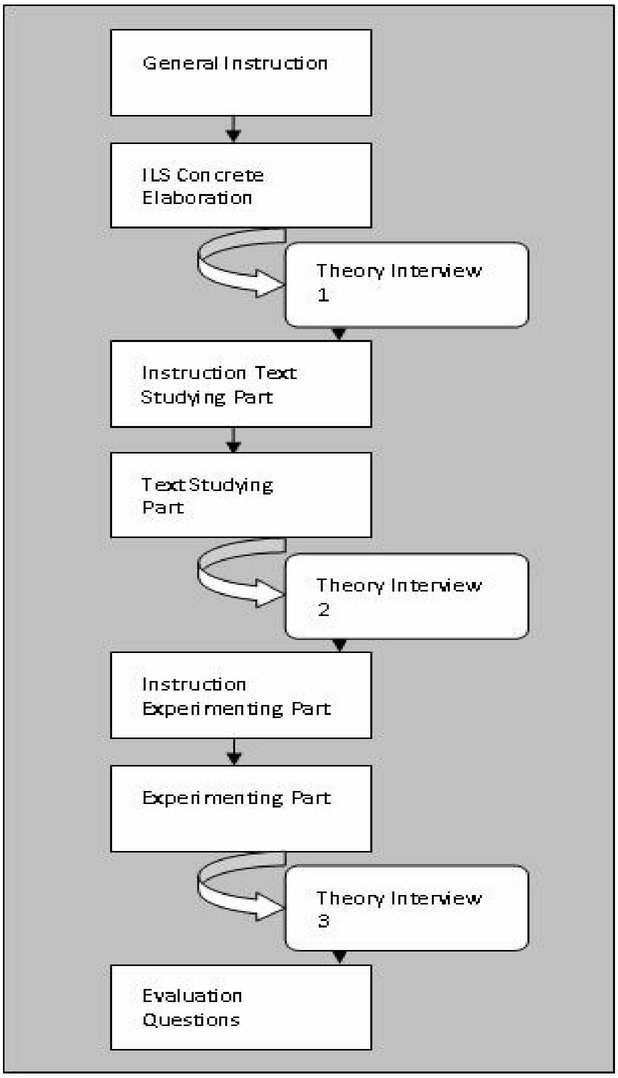

Figure 2. *Experimental Procedure.*

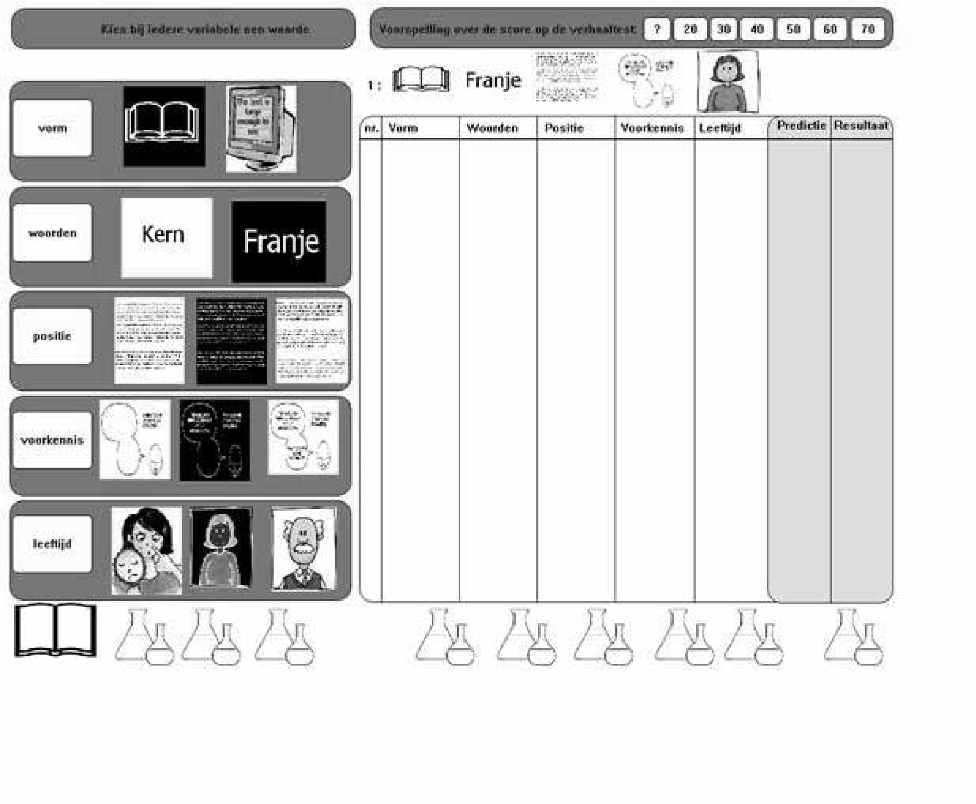

Figure 3. *Interface of the Experiment Environment.*

Results

Results will be presented according to the programme of the student: first studying, then experimenting. Next, the division of time and effort between studying and experimenting will be analyzed. Eventually, the outcomes of the evaluation questionnaire will be presented.

Studying

Number of paragraph visits and study time. The first step in the analysis was a comparison of the number of paragraph visits of high and low CE students. Table 1 displays the data. There was no difference between high and low CE students in number of paragraph visits ($F < 1$). The effect of Type of Paragraph (theory versus example) was significant (F (1, 74) = 30.52, p < .01). Students read more theory paragraphs (M = 10.68, SD = 4.85) than example paragraphs (M = 5.99, SD = 5.48). Overall, the students spent almost twice as much time on theory paragraphs (M = 422.95 sec, SD = 247.08) in comparison with example paragraphs (M = 225.67 sec, SD = 233.18). This difference was significant (F (1, 74) = 25.19, p < .01). High CE students

(*M* = 212.97 sec, *SD* = 214.36) spent less time on example paragraphs than low CE students did (*M* = 238.37 sec, *SD* = 252.85), whilst high CE students (*M* = 479.66 sec, *SD* = 269.13) spent more time on theory paragraphs than low CE students (*M* = 366.24 sec, *SD* = 211.45), but the interaction effect was not significant *(F* (1, 74) = 3.12, *p* = .082).

Table 1. Number of Paragraph Visits and Reading Time per Chapter Type and Level of Concrete Elaboration.

	Concrete Elaboration							
	Low n = 38				High n = 38			
	Theory Paragraphs		Example Paragraphs		Theory Paragraphs		Example Paragraph	
	M	Sd	M	sd	M	sd	M	sd
Number of Visits	10.37	4.98	6.39	6.00	11.00	4.76	5.58	4.96
Reading Time (secs)	366.24	211.45	238.37	252.85	479.66	269.13	212.97	233.18

The data suggested that some students had an articulated preference for reading theory paragraphs, whereas other students exclusively chose example paragraphs. Therefore, a new independent variable was introduced, Paragraph Preference, with three levels: (0) No preference for reading either theory paragraphs or example paragraphs; (1) preference for reading example paragraphs (number of read example paragraphs outnumbers the number of read theory paragraphs with 3 or more); (2) preference for reading theory paragraphs (number of read theory paragraphs outnumbers the number of read example paragraphs with 3 or more). Table 2 shows the number of participants in each of the three categories, cross-tabulated with Level of Concrete Elaboration.

Table 2. Number of Students in Each of Three Levels of Paragraph Preference (No Preference; Example Preference; Theory Preference) by Level of Concrete Elaboration.

	Level of Concrete Elaboration	
Paragraph Preference	Low	High
No Preference	10	13
Example Preference	7	3

As Table 2 shows, students with an example preference are small in number and most of them belong to the category of low CE students. Interestingly, the students with a theory preference are evenly distributed over the groups of low and high CE students. A chi-square test does not reveal a clear dependency between the two dimensions (X^2 (2) = 2.02, p = .37). Therefore, both variables were included in subsequent analyses.

Table 3. Performance on Three Theory Interviews by Low and High CE Students with No Paragraph Preference, an Example Preference and a Theory Preference.

	Theory Interview					
	First		Second		Third	
Paragraph Preference	M	sd	M	sd	M	sd
No Preference						
Low CE (n = 10)	4.90	2.51	5.10	2.56	6.90	2.88
High CE (n = 13)	5.15	2.38	4.15	1.57	7.31	4.27
Example Preference						
Low CE (n = 7)	3.29	1.89	5.29	2.75	5.43	1.40
High CE (n = 3)	4.33	3.06	2.67	2.08	3.00	2.00
Theory Preference						
Low CE (n = 21)	5.81	2.62	6.76	2.81	7.43	2.69
High CE (n = 22)	5.27	2.03	5.50	2.76	7.27	2.19

Learning Outcomes. Learning outcomes were analyzed by comparing the performance on the first and second theory interview, administered before and after studying the text. Table 3 provides the details.

An Analysis of Variance with Paragraph Preference and Level of Concrete Elaboration as factors, and score on the Second Theory Interview as dependent variable revealed a significant effect of Paragraph Preference (F (2, 70) = 4.07, p < .05). Students with a theory preference scored highest on the theory interview (M = 6.13, SD = 3.41), followed by students with no preference (M = 4.63, SD = 4.70) and students with an example preference (M = 3.98, SD = 7.71). The effect of Level of Concrete Elaboration was also significant (F (1, 70) = 4.75, p < .05). Unexpectedly, low CE students scored higher on the second theory interview (M = 5.72, SD = 4.01) than high CE students (M = 4.11, SD = 5.02). The interaction between both factors was not significant (*F* < 1). The data suggest that both main effects were boosted by the low scoring group of high CE students who preferred example paragraphs.

Experimenting

Process Variables. The process of conducting experiments was analyzed with three process variables: Number of Experiments, Time per Experiment, and application of the Control of Variables Strategy (CVS). No effects of Paragraph Preference or Level of Concrete Elaboration were found for Number of Experiments. Students conducted on average 15.1 experiments (*SD* = 5.91; all *F*s < 1). This means that almost all students stopped experimenting after the minimum required number of 15 experiments had been reached.

Students spent on average 28.91 secs per experiment (*SD* = 9.04). Students with no preference for theory or example paragraphs spent more time (*M* = 33.50 secs, *SD* = 11.02) on an experiment than either students with a preference for example paragraphs (*M* = 23.93 secs, *SD* =5.28) or students with a preference for theory paragraphs (*M* = 27.61 secs, *SD* = 7.56). The main effect of Paragraph Preference was significant (F (2, 70) = 4.86, p < .05). The differences between the No Preference group and either the Theory Preference or the Example Preference group were both significant at 5% level (Tukey's Test). The difference between the latter two groups was not significant. There was no effect of Level of Concrete Elaboration on time per experiment, neither was the interaction between Paragraph Preference and Level of Concrete Elaboration significant (all *F*s < 1).

Students did not significantly differ in varying values of independent variables between experiments (*M* = 2.99, *SD* = .62). So, on average students varied three variables at a time, instead of the ideal one variable. Students with various levels of Concrete Elaboration or various paragraph preferences did not differ in applying the Control of Variables Strategy (all *F*s < 1).

Learning Outcomes. Learning outcomes were assessed during the final theory interview. Table 3 provides the data. An Analysis of Covariance with Paragraph Preference and Level of Concrete Elaboration as independent variables, performance on the second theory interview as covariate, and performance on the third theory interview as dependent variable, revealed a significant increase (F (1, 69) = 5.16, p < .05) in performance in the theory interview, from interview 2 (*M* = 5.43, *SD* = 2.69) to interview 3 (*M* = 6.93, *SD* = 2.90). Moreover, the effect of Paragraph Preference was significant (F (2, 69) = 3.22, p < .05). Students with a theory preference scored highest (*M* = 7.35, *SD* = 2.42), followed by students with no preference (*M* = 7.13, *SD* = 3.66) and students with an example preference (*M* = 4.70, *SD* = 1.89). There was no effect of Level of Concrete Elaboration (*F* < 1), nor an interaction effect (*F* < 1).

Studying and Experimenting

The final step in the data analysis focused on the factors which influenced the learning outcomes as assessed by Theory Interview 3. Particularly, we were interested in the relative contribution of prior knowledge, studying effort and experimenting effort, to the final theory interview score. A regression analysis was conducted including score on Theory Interview 1, total example reading time, total theory reading time, score on Theory Interview 2, score on the Control of Variables Strategy measure, and time per experiment. Taken together, these predictor variables explained a significant proportion of variance in scores on Theory Interview 3, R^2 = .38, F (6, 69) = 7.02, p < .01). Table 4 presents the results of the regression analysis. The contribution of prior knowledge about human memory (Theory Interview 1) was marginally significant, β = .22, t (69) = 1.89, p < .06. Example Reading Time did not deliver a significant contribution to the variance in Theory Interview 3 scores, but the contribution of Theory Reading Time was significant, β = .28, t (69) = 2.70, p < .01. The score on Theory Interview 2 did not add to the variance of Theory Interview 3 scores. But both predictor variables representing the process of conducting, significantly predicted the Theory Interview 3 scores, β = -.29, t (69) = -2.83, p < .01 for the Control of Variable Strategy variable, and β = .21, t (69) = 2.14, p < .04 for Time per Experiment. The conclusion is that, apart from prior knowledge, time invested in reading theory paragraphs, carefully manipulating one variable at a time and seriously considering individual experiments, all predict the performance on the final interview, whereas time invested in reading examples does not.

Table 4. Results of the Regression Analysis

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	SE	β	t	p <
Constant	5.11	1.94		2.64	.01
Theory Interview 1	.26	.14	.22	1.89	.06
Example Time	.00	.00	.09	.96	.34
Theory Time	.00	.00	.28	2.70	.01
Theory Interview 2	.16	.12	.15	1.31	.20
Control of Variables	-1.34	.47	-.29	-2.83	.01
Time per Experiment	.07	.03	.21	2.14	.04

Evaluation Questionnaire

Table 5 shows the means and standard deviations of the responses on the 10 evaluation statements. Students least agreed on statement 6 which stated that they did not make use of the text they had read in preparation for experimenting. They also scored rather low on statement 3, which stated that they tended to start with examples. Very positive responses were recorded on statement 10, which stated that a surplus learning effect should be expected when reading and experimenting is put together. Not much difference was found between statements 8 and 9, which stated that reading and experimenting had the biggest impact on the learning outcome, respectively. Most interesting for our purposes is to find out whether the reported tendency to start with theory paragraphs (statement 4) as opposed to example paragraphs (statement 3) is in accordance with the reading behaviour as registered in the log files. The correlation between the score on statement 4 (tendency to start a new chapter with theory paragraphs) and the number of chapters in which the student actually started with reading a theory paragraph was $r = .73$, $p < .01$, and the corresponding correlation between the score on statement 3 (tendency to start a new chapter with example paragraphs) and the number of chapters in which the student actually started with reading an example paragraph was $r = .57$, $p < .01$.

Table 5. Means and Standard Deviations Evaluation Questionnaire (1 = Totally Disagree; 5 = Totally Agree), N = 54.

	Statement	M	sd
1	I learned the most about the subject (memory) in the experimental component of the learning environment.	3.44	1.06
2	I learned the most about the subject (memory) in the reading component of the learning environment.	3.33	1.12
3	In the reading component of the learning environment I tended to start a new chapter with examples.	2.81	1.17
4	In the reading component of the learning environment I tended to start a new chapter with theory descriptions.	3.41	1.19
5	During conducting the experiments I thought of what I had read in the reading component.	3.91	.78
6	During conducting the experiments I did not use what I had read.	2.17	.91
7	This design could (texts in combination with simulation experiments) well be deployed in other domains (e.g. biology).	3.46	.93

8	I learned the most about the subject (memory) in the reading component of the learning environment.	3.56	.95
9	I learned the most about the subject (memory) in the experimental component of the learning environment.	3.26	1.32
10	The two components of the learning environment together allow a surplus learning effect.	4.06	.86

Discussion

The most remarkable result of this study was the finding that both studying an expository text and conducting experiments in a simulation environment contributed to the performance on a comprehension test in which participants had to explain the relationship between factors determining memory processes and memory performance. Moreover, it was found that particularly gaining more in-depth knowledge of theoretical explanations of memory processes helped students to develop their understanding of the subject matter. The quality of the process of conducting experiments, as measured by the time invested in every experiment and the number of variables varied at a time (Veenman, Wilhelm & Beishuizen, 2004), was also a significant contributor to the variance in scores in the final comprehension test.

Focusing on the reading part of SEE alone, a clear-cut preference for reading theory paragraphs was found, both in number of theory paragraphs read and in time devoted to reading paragraphs. More than half of the students (to be exact: 57%) showed a preference for reading theory paragraphs. Students with a preference for studying theory paragraphs performed better on the second Theory Interview, right after the study period. In the theory interview, students were asked to predict what the relationship would be between several variables and performance on a memory task. Apparently, studying theory paragraphs formed a more effective preparation for such a comprehension task than studying example paragraphs.

All students preferred theory to example paragraphs to some degree, but high CE students spent more time on reading theory paragraphs than low CE students, whereas the reverse held for low CE students.

To sum up, this experiment clearly confirmed the findings by Beishuizen et al. (2002, 2003) and Jonker, Beishuizen, and Veenman (submitted) that high CE students have a preference for studying theory explanations, whereas low CE students tend to focus on example paragraphs. Although in this experiment the consequential task was not a comprehension test but a new assignment, discovering the relationship between memory performance and various individual and task characteristics, students maintained their theory orientation. Perhaps, they chose to stick to theory explanations because of the nature of the consequential task: Developing and testing hypotheses about memory processes.

No difference between high and low CE students showed up in amount of time spent on reading the expository text, or in the amount of paragraphs studied. So, the data do not support the idea that high CE students tend to study more efficiently than low CE students who simply accumulate as much information as possible because they lack a proper concrete elaboration strategy.

Students were quite aware of their strategies and of the role studying and experimenting played in the construction of a proper understanding of the domain. The evaluation questionnaire showed that students considered both studying and conducting experiments as important learning activities. They understood that both activities can mutually support each other. Interestingly, their recollection of the preference they gave to either theory paragraphs or example paragraphs was confirmed by the logs of their actual reading strategies.

It appeared that Level of Concrete Elaboration played no role in the process of conducting experiments. High and low CE students did not behave differently as far as quality of conducting experiments is concerned, or understanding of the domain as exposed during the final Theory Interview. Apparently, the scope of the learning style is confined to knowledge acquisition from expository texts. This may be an important conclusion because it puts a restriction on the use of Vermunt's (1992; 1998) concept of Concrete Elaboration. However, the task of conducting experiments in a simulation environment can be considered as rather new for the students in these experiments. Lack of experience may have prevented the students from activating their preferred learning style. Prolonged practice in the simulation environment might enable students to approach the task more strategically, in accordance with their learning style. However, inexperienced as they may have been, they still varied in the amount of attention paid to each experiment and in the number of variables varied at a time and these differences in quality of experimenting played a significant role in the performance during the final Theory Interview.

What is the meaning of this experiment in the light of the two explanation for strategic differences between high and low concrete elaboration students? If, in accordance with Klahr and Dunbar (1988), we consider the process of studying the expository text as representing the exploration of the hypothesis space and the process of conducting experiments as a concrete manifestation of working in the experiment space, than we can conclude that students did not display clear preference for either a theorist approach or an experimenter approach. Our instructions may have prevented the students from acting according to their preferred style of inquiry learning. Students had to read at least one single page of every chapter and conduct at least 15 experiments before that could end their work in the simulation environment. So, these conditions may have forced the students into quite a restrictive straitjacket. However, time devoted to reading theory paragraphs was a valuable predictor of performance on the final Theory Interview.

That is to say, acting as a genuine theorist meant a successful strategy in our study and experiment environment.

On the two pairs of explanation, induction versus deduction and adaptation versus accumulation, we argue as follows. The outcome that the learning style Concrete Elaboration has a distinguishing impact on reading, and not on experimenting leads us to two possible explanations. First, the lack of effect for the simulation part might be the result of novelty. Manipulating variables in order to test hypotheses is not something the students are expected to be familiar with, as opposed to reading for understanding. A second explanation however, is that the adaptation versus accumulation approach is not able to explain all behaviour shown in the learning environment, and the deduction versus induction explanation comes out as the more parsimonious explanation of the two with respect to the whole task. In addition to this overall argument against adaptation versus accumulation, the results on the reading part of the learning environment alone do not favour adaptation versus accumulation either: No difference in reading time was found between high and low concretizers.

The practical implications of this study are quite straightforward. First of all, the study and experiment environment (SEE) was appreciated by the students as a valuable enrichment of their learning environment. Therefore, SEE may play a role in upper secondary education to help students develop an appropriate set of inquiry skills. Teachers may use the environment to let students experience the value of expository texts in order to be prepared to enter a particular domain of (scientific) inquiry. Furthermore, students can be trained to apply appropriate inquiry strategies, for instance, the Control of Variables Strategy (Beishuizen, Wilhelm, & Schimmel, 2004; Veenman, Wilhelm, & Beishuizen, 2004). Secondly, SEE may accommodate for individual differences in learning styles, like concrete elaboration. Because we have seen differences in study behaviour and not in experimenting behaviour, one might conjecture that students could develop their own styles of approaching the study task without putting one group of students with a particular reading strategy in favour of other groups of students.

References

Beishuizen, J., Stoutjesdijk, E., & van Putten, K. (1994). Studying textbooks: Effects of learning styles, study task, and instruction. *Learning and Instruction*, 4(2), 151.
Beishuizen, J., Wilhelm, P., & Schimmel, M. (2004). Computer-supported inquiry learning: Effects of training and practice. *Computers & Education*, 42(4), 389-402.
Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology*, 73(3), 291-316.
Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology* (72), 279-297.
Beishuizen, J. J., & T. Stoutjesdijk, E. (1999). Study strategies in a computer assisted study environment. *Learning and Instruction*, 9(3), 281.
Brewer, W. F., & Lichtenstein. (1982). Stories are to entertain: A structural-affect theory of stories. *Journal of Pragmatics, 6*, 473-486.
Chi, M.T.H., & VanLehn, K.A. (1991). The content of physics self explanations. The *Journal of the Learning Sciences*, 1(1), 69-105.
De Jong, T., & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*, 179-202.
De Jong, T., Beishuizen, J. J., Van Someren, M., Veenman, M., Hulshof, C., Wilhelm, P., et al. (2005). *Determinants of discovery learning in a complex simulation environment*. In U. Riss & P. Johansson (Eds.), *Cognition, Education and Communication Technology*. Hillsdale, NJ: Erlbaum.
Hulshof, C. D., Wilhelm, P., Beishuizen, J. J., & Van Rijn, H. (2005). FILE: A tool for the study of inquiry learning. *Computers in Human Behavior*, 21(6), 945-956
Jonker, H. G., Beishuizen, J. J., & Veenman, M. V. J. (Submitted). Understanding an expository text – a process analysis. *British Journal of Educational Psychology*.
Klahr, D., & Dunbar, K. (1988). Dual-Space Search During Scientific Reasoning. *Cognitive Science*, 12(1), 1-48.
Schauble, L. (1996). The development of scientific reasoning in knowledge-rich contexts. *Developmental Psychology*, 32(1), 102-119.
Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction, 14*(1), 89.
Vermunt, J. D. H. M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken*. Swets & Zeitlinger, Amsterdam.
Vermunt, J. D. H. M. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology* (68), 149-171.
Wiese, B. S., Sauer, J., & Rüttinger, B. (2004). Consumers' use of written product information. *Ergonomics*, 47(11), 1180-1194.

Wilhelm, P. (2001). *Knowledge, skills and strategies in self-directed inductive learning*. Unpublished PhD, Leiden University, Leiden.

Wilhelm, P., & Beishuizen, J. J. (2003). Content effects in self-directed inductive learning. *Learning and Instruction*, 13(4), 381.

Wilhelm, P., & Beishuizen, J. J. (2004). Asking questions during self-directed inductive learning: Effects on learning outcome and learning process. *Interactive Learning Environments*, 12(3), 251 - 264.

Wilhelm, P., Beishuizen, J. J., & Van Rijn, H. (2005). Studying inquiry learning with FILE. *Computers in Human Behavior*, 21(6), 933-943

Chapter 6 General Discussion

In order to acquire knowledge one ought to have prior knowledge of equal complexity as the knowledge to-be-learned. This is what Bereiter (1985) called the Learning Paradox. In the research reported here, the problem of the Learning Paradox has been addressed by adding a new dimension: the student's learning style. Students differ in the extent to which they spontaneously generate episodes of personal experience when they encounter concepts and rules presented in a study text. Vermunt (1992) called this habit Concrete Elaboration (CE). Four experiments were conducted to disentangle a previously found aptitude-treatment interaction between the learning style Concrete Elaboration (high and low) and the nature of the learning task (inductive versus deductive approach).

Beishuizen, Stoutjesdijk, Spuijbroek, Bouwmeester, and Van der Geest (2002) found that in a group of students who received a rule-oriented training to apply the Rule of Large Numbers to solve a series of statistical problems, a high level of Concrete Elaboration enhanced the score on the posttest. However, in a group who received an example-oriented training, a high level of Concrete Elaboration lowered the results on the posttest. Beishuizen, Asscher, Prinsen, and Elshout-Mohr (2003) found in a text-studying experiment that high CE students scored better than low CE students on questions about paragraphs without examples or with an irrelevant example, whereas low CE students outperformed high CE students on questions about paragraphs with a main idea and two or five examples.

Both studies revealed that high CE students are more successful when reading a theory-oriented expository text and low CE students profit from an example-oriented expository text. As a result of their study, Beishuizen et al. (2003) suggested two interpretations of the Concrete Elaboration learning style: (1) The adaptation versus accumulation explanation, or (2) the deductive versus inductive learning explanation.

According to the <u>adaptation versus accumulation explanation</u>, high CE students take their own knowledge as point of departure: On encountering a concept in a study text, they adapt existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. The may actually be led astray by too many examples. Low CE students do not activate existing knowledge to the same extent and try to accumulate as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

The alternative <u>deductive versus inductive learning explanation</u> is inspired by Chi and VanLehn (1991) who showed that students, studying physics examples, generated two kinds of explanations: The first type of explanation indicated a deductive approach: instantiating a general principle with information in the example statement. The second type indicated an inductive approach: generalization and extension of the example statement. To put it differently, readers may reason either from general principles to examples by taking the principle as point of departure (the deductive approach), or from examples to general principles (the inductive approach) by abstracting general principles from examples. High CE students would adopt the deductive approach whereas low CE students would prefer the inductive approach.

What is the relationship between these two explanations and the Learning Paradox? Bereiter has interpreted Meno's Paradox as follows: "If one has tried 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." (Bereiter, 1985, p. 202). Bereiter (1985) suggested 10 solutions for overcoming the Learning Paradox. As part of his last solution, Bereiter emphasized that human beings “constantly imposing coherence on thoughts, feelings, and behavior that emanate from parts of the brain having only limiting communication with one another” (p. 205). According to Bereiter, the discovery of consistency in one’s own behaviour is the basis for the process of abstraction. This process of abstraction is also known as induction. Holland, Holyoak, Nisbett, and Thagard (1989) defined induction as “all inferential processes that expand knowledge in the face of uncertainty” (p. 8). So, induction is a well documented candidate process for explaining part of the Learning Paradox: Human beings “experience” or “see” coherence in various events or examples merely because it exists out there and somehow hits the eye, like patterns in the visual field (Gibson, 1979). However, Vermunt’s concept of Concrete Elaboration (1992, 1998) does not take concrete experience as a point of departure. Instead, theory explanations are for high CE students the source of inspiration to activate concrete experience. The question is whether this activation of relevant prior experience presupposes “understanding” the concept or theory in question. Are students able to understand the concept of visual illusion by reading a definition and remembering an event in which an illusion, e.g., the moon illusion, was experienced?
In this study we attempted to unravel this question by:

- presenting students - with low and high scores on Vermunt’s Concrete Elaboration scale - with study texts that included theory explanations and examples;
- asking them to think and read aloud;
- measuring reading times;
- asking them to rate the chapters with many theories and many examples on readability; and
- taking comprehension posttests afterwards.

These experiments were reported in Chapters 2 and 3. Let us review the findings. A general conclusion is that students are in general more engaged in studying theory explanations than examples. This was concluded in Chapter 2 on the basis of reading and thinking aloud data, in Chapter 3 on the basis of reading times and readability judgments, and in Chapters 4 and 5 on the basis the choices students made in a hypertext environment. This theory-oriented attitude of the students may have various causes. One explanation is that these 17 and 18 year-old upper secondary school students know through their own experience that theory explanations are a more valuable vehicle for understanding and knowledge construction than examples. Many of our students prepare for university education and may therefore be inclined to focus on theories at the expense of examples in study texts. Another explanation is that the educational environment of these students: the teachers, the assignments, the textbooks, the tests, have all directed the students' attention towards theories as the most important focus for learning and understanding.

Interestingly, the data did not confirm that a focus on theories leads to better performance on a comprehension test. The data were not completely unequivocal, and one of the two hypertext experiments (Chapter 4) students did perform better on questions about all-example chapters than on questions about all-theory chapters. This confirmed earlier findings by Beishuizen et al. (2002) and Beishuizen et al. (2003). However, when students study a text in order to prepare for conducting an experiment, then a focus on theory paragraphs is beneficial for eventually understanding the relationships between the variables in the domain of investigation, as the experiment in Chapter 5 showed. The lack of a clear advantage of studying theory paragraphs may be caused by the fact that the experimental texts in this study were all created in such a way that there existed a one-to-one correspondence between theory paragraphs and example paragraphs. In each chapter of every text, all paragraphs were written on the framework of a previously determined set of concepts of theoretical arguments. So, the experimental texts did allow for equal performance on a comprehension test on the basis of either studying theory paragraphs or example paragraphs. However, the possibility should be envisioned that our posttests were not sensitive enough to record differences between students studying theory paragraphs or example paragraphs.

So, a preference for studying theoretical explanations at the expense of examples appeared to belong to the basic set of study habits of almost all students engaged in our experiments. But this study was initiated to shed more light on the concept of Concrete Elaboration, giving concrete form to abstract concept and theories (Vermunt, 1992, 1998). The reading and thinking aloud experiment provided support to Vermunt's conception in that a lot of deductive elaborations were identified in the reading and thinking aloud protocols. High CE students did behave as expected by the results of the Concrete Elaboration scale of the Inventory of Learning Styles. This means an important validation of this part of Vermunt's instrument. High CE students did behave as they had indicated by evaluating the statements in the inventory. However, this behaviour was more clear-cut when a rather difficult text was offered. In a relatively simple text many concept-in-the-text to concept-in-the-mind and example-in-the-text to example-in-the-mind elaborations were observed. These direct mappings were unforeseen. Apparently, it is possible to directly activate a concept stored in semantic memory by studying a concept in a study text, as well as associate examples in a text with personal experiences stored in episodic memory (Tulving, 1972). Of course, these direct mappings presuppose the existence of relevant concepts in semantic memory and relevant experiences in episodic memory. So, by themselves these mappings do not offer a new solution to the Learning Paradox. But if we assume that inductive processes, which were not recorded during the thinking and reading aloud sessions, operate in an autonomous and automatic way, these mappings at least offer alternative routes to constructing knowledge. For instance, an association between examples in the text and experiences in episodic memory may, by induction, be abstracted into a new concept, which could not have been formed without such an association. A partially unknown concept in the text may be better understood by giving concrete form to the meaning of the concept (deductively) or by associating the concept with a concept in the mind, which, in its turn, may deductively lead to activation of experiences in episodic memory. Figure 1 presents a hypothetical model of the construction of a new concept in which four types of elaborations are distinguished.

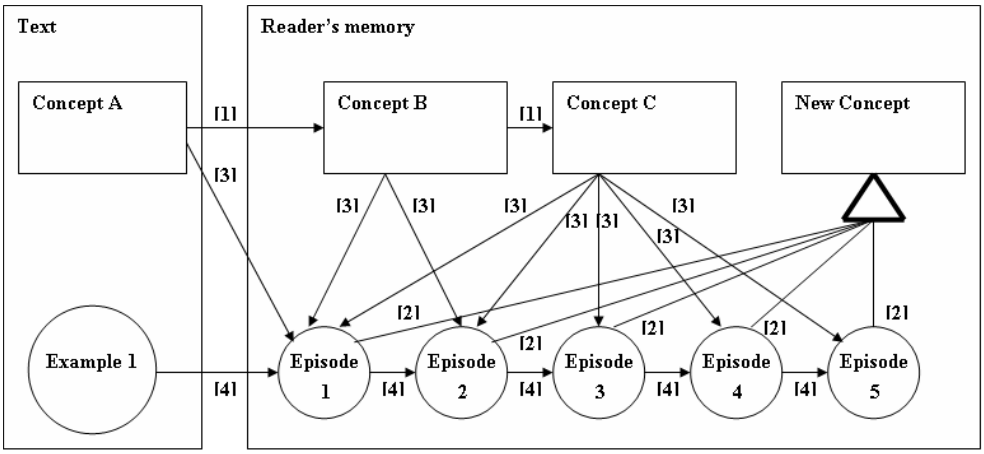

Figure 1. Hypothetical Model of the Construction of a New Concept by Interaction Between Text and the Reader's Memory. Four Types of Elaborations are Distinguished in the Model: [1] Conceptual Elaboration, [2] Inductive Elaboration, [3] Deductive Elaboration, and [4] Instance Elaboration.

1. <u>Conceptual Elaborations</u>. This is a type of elaboration in which students relate theory descriptions to their existing conceptual network. Students seem to directly connect a concept-in-the-text with a concept-in-the-mind. They do not report any intermediary role of concrete examples or experiences stored in their episodic memory. So, it appears that students are able to search for related concepts whenever they encounter a concept in a study text. This goal-oriented searching seems to be a conscious process. A partially understood concept can be further explored in this

way, and, eventually, its meaning can be adapted or even restructured. However, when a concept is unknown to the reader, it is unlikely that the reader will find any related concepts in his or her semantic memory. In that case, the reader may be able to use the examples added to the description of the concept in order to activate similar episodes of personal experience in episodic memory.

2. Inductive Elaborations. This type of elaboration, in which students elaborate at a conceptual level on examples in the text or on episodes of personal experience in the reader's memory, refers to the process of induction. One might envisage that this kind of elaboration signifies the process of constructing new knowledge. The fact that we did not find traces of this process in the reading and thinking aloud protocols does not imply that readers do not apply inductive processes to understand and represent the meaning of expository texts. Rather, it is assumed that these processes, with respect to text comprehension, are not amenable to conscious control. Therefore, in the model in Figure 1 these processes are located within the reader's memory. There is no direct link between examples in the text and concepts in the reader's mind.

3. Deductive Elaborations. Readers apply an abstract concept stored in memory or embedded in an expository text as a theory description by activating episodes of personal experience. These elaborations represent the process of concrete elaboration as described by Vermunt (1992). In the reading and thinking aloud study, reported in Chapter 2, we found a lot of comments referring to this category of elaborations. Therefore, we assume that this process is at least partially under conscious control.

4. Instance Elaborations. These elaborations extend the representation of the text at a concrete level by adding examples or concrete episodes in the mind to the examples in the text. This kind of elaboration seems, at first sight, quite redundant. However, one might envisage that this process prepares the reader for inducing a new concept. By spreading of activation (Lorch, 1982): episodes, which are activated by examples in the text, spread their activation over other episodes. Together, they trigger a process of inductive elaboration which leads to the construction of a new concept. We call this category *instance elaborations*, emphasizing that instances of concepts in the text are related to instances of concepts in the episodic memory. The fact that we found traces of this process in the thinking and reading aloud data of the study reported in Chapter 2 makes it probable that at least part of this process is consciously controlled. In terms of Ericsson and Simon (1980, 1993), the products of the process of instance elaboration are stored in short-term memory and can be reported in a thinking aloud condition.

This hypothetical model of knowledge construction allows for various pathways to the construction of new concept. High CE students are supposed to depart from the concepts in the text and use both conceptual elaboration (route [1] in Figure 1) and deductive elaboration (route [3] in Figure 1) to activate relevant concepts and episodes of personal experiences. These episodes form the basis for the inductive construction of new concepts. Low CE students are supposed to depart from the examples in the text and use instance elaboration and spreading of activation to activate an appropriate set of episodes of personal experience as the basis for the inductive construction of new concepts.

The inductive step is necessary to construct new knowledge. This inductive process does not appear to be very open to conscious control in our text comprehension studies. We did not record traces of it during the collection of reading and thinking aloud protocols in the study reported in Chapter 2. Rather, it is assumed that activating many relevant examples and episodes may start up the induction process. Existing concepts serve as a valuable filter in the process of activating episodes. Spreading of activation is not a “principled” process, and may, therefore, lead to activation of irrelevant episodes. This condition makes the process of knowledge construction for low CE students more hazardous. Because they do not make use of conceptual elaboration, they lack the power of existing concepts as supervisors of the activation process. If induction is not triggered, then the process is more a matter of accumulation of examples than a matter of knowledge construction by induction. Therefore, the alternative models presented above, the deductive versus inductive learning explanation and the adaptation versus accumulation explanation of the concept of concrete elaboration may converge to one interpretation, displayed in Figure 1. An incomplete process of knowledge construction leads to accumulation of examples and episodes, no new concepts are constructed because the process of induction fails. A complete process of knowledge construction leads to inductive learning because the activated episodes trigger the induction process and a new concept is the result of this process.

Several references to the experiments reported in the previous chapters were made. To complete this review and interpretation of the findings of this study, a summary is made of the evidence supporting the model of knowledge construction by elaboration. The reading and thinking aloud data of Chapter 2 formed the main source of inspiration for the model. The lack of traces of inductive elaboration in the reading and thinking aloud protocols has been represented in the model, by leaving a direct connection between examples in the text and concepts in the reader’s memory, out of the model.

The data of Chapter 3 showed that studying theory paragraphs took a lot of reading time. Theory paragraphs were assessed as difficult to read. The model caters for these data, if we assume that conceptual elaboration and deductive elaboration are relatively conscious processes which require attention and effort. The experiments in Chapter 3 did not reveal striking differences between low CE and high CE students. Low CE students spent more time reading theory paragraphs than reading example paragraphs. This is accounted for by the model by assuming that low CE students have the habit of using examples in the text to activate episodes of personal experience and, consequently, find the use of theory paragraphs more troublesome. The fact that high CE students consider chapters *starting* with a theory paragraph as more difficult to read than chapters *ending* with a theory paragraph may be explained by the preferred route high CE students take: from conceptual elaboration via deductive elaboration to inductive elaboration. So, the internal deductive processes receive more attention than external processes which are necessary to relate concepts to examples in the text. This kind of external deductive elaboration was not noticed in the thinking and reading aloud data of Chapter 2 and was, consequently, not included in the model. Perhaps an extension is necessary here. Anyway, high CE students do not seem to have a lot of experience with building external relationships between concepts and examples in the text. Therefore, they consider chapters with a concept in the first paragraph as more difficult than paragraphs with a concept in the last paragraph.

The data of Chapter 4 reveal that students have the general habit of focusing on theoretical explanations. This habit coincides with the reading strategy of high CE students. In a hypertext learning environment, allowing for cognitive flexibility, low CE students gradually discover that their preferred route is a viable approach: association of examples in the text with episodes of personal experience, followed by spreading of activation towards other episodes and, eventually, by inductive construction of new concepts.

Finally, the data in Chapter 5 confirmed the value of both exploring theoretical explanations in a study text and conducting experiments in order to arrive at understanding of the subject matter. That is to say, students use routes, conceptual elaboration and instance elaboration to construct knowledge. The interesting finding of Chapter 5 is that the model of knowledge construction by elaboration can be considered incomplete because it tacitly presupposes that the outer world always provides the stimuli which trigger a response by the learner. In that sense, the model is in fact a modern variant of the old Stimulus Response model (Neisser, 1976). If we rethink the model as a variant of the empirical cycle (De Groot, 1961), then concepts in the individual's mind can also activate concrete experiences in order to test the validity of a hypothesis. In fact, the empirical cycle and the internal model of knowledge construction by elaboration are similar. In both processes, deduction and induction take turns in the process of knowledge construction. Empirically, hypotheses are deduced from theories and subsequently tested by conducting experiments. The concrete results of these experiments lead, by induction, to further extension or deepening of the theoretical framework. Likewise, the internal process of knowledge construction by elaboration also draws upon the interchange between deduction, using concepts to activate episodes of personal experience, and by induction, abstracting new concepts from activated episodes. The study reported in Chapter 5 showed that both processes contribute to understanding the subject matter. However, the distinction between high and low CE students does not seem to be useful in the domain of learning by studying and experimenting. Although the distinction between deduction and induction seems valid, there appears to be no straightforward match between the distinctions between high and low CE students and Klahr and Dunbar's (1988) distinction between theorists and experimenters.

The model of knowledge construction by elaboration has two implications for education. The first one is that examples and episodes of personal experience are necessary and indispensable in the process of knowledge construction. The model does not allow for a direct creation of new concepts by activating existing concepts. So, the model is in line with constructivist views on learning and knowledge acquisition which emphasize the importance of practical experience (cf. CTGV, 1992). Students should be given ample opportunity to construct knowledge by studying examples of the concepts to be learned. This supports the process of knowledge construction and allows students with various learning styles to choose different routes to understanding.

Secondly, the model shows that theoretical explanations can be guiding in the process of knowledge construction. Through the processes of conceptual and deductive elaboration, concepts can serve as a guiding source for generating relevant episodes of personal experience. Students should learn to use concepts as guidelines and to use relevant experience to construct new concepts. In this way, both high and low Concrete Elaboration Students can learn to overcome the Learning Paradox.

References

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology, 73*(3), 291-316.

Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology, 72,* 279-297.

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*(2), 201 - 226.

CTGV (Cognition and Technology Group at Vanderbilt University) (1992). Technology and the design of generative learning environments. In Th. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction* (pp. 77-91). Hillsdale, NJ: Erlbaum.

Chi, M. T. H., & VanLehn, K. A. (1991). The content of physics self-explanations. *Journal of the Learning Sciences, 1*(1), 69-105.

De Groot, A.D. (1961). *Methodologie. Grondslagen van onderzoek en denken in de gedragswetenschappen* [Methodology. Foundations for research and thinking in the behavioral sciences]. Den Haag: Mouton & Co.

Elshout-Mohr, M., & Van Daalen-Kapteijns, M.M. (1985). Het leren van begrippen, in het bijzonder in het eerste stadium van het hoger onderwijs. [On acquiring concepts, in particular during the first phase of higher education.] *Pedagogische Studiën, 62*, 459 - 470.

Ericsson, K. A. & Simon, H. A. (1980). Verbal reports as data. *Psychological- Review, 87,* 215.

Ericsson, K. A. & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data (rev. ed.)*. Cambridge: MIT Press.

Gibson, J.J. (1979). *The ecological approach to visual perception*. Hillsdale, NJ: Erlbaum.

Holland, J.H., Holyoak, K.J., Nisbett, R.E., & Thagard, P.R. (1989). *Induction. Processes of Inference, Learning, and Discovery*. Cambridge, MA: Bradford Books/MIT Press.

Klahr, D., & Dunbar, K. (1988). Dual space search during scientific reasoning. *Cognitive Science, 12*, 1-48.

Lorch, R. F. (1982). Priming and search processes in semantic memory: A test of three models of spreading activation. *Journal of Verbal Learning and Verbal Behavior, 21*, 468-492.Neisser, U. (1976). *Cognition and reality*. San Francisco: W.H. Freeman & Co.

Neisser, U. (1976). *Cognition and reality*. San Francisco: W.H. Freeman & Co.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.). *Organization of memory* (pp. 382 - 405). New York: Academic Press.

Chapter 7 Summary

Theoretical background

This study started with a set of straightforward questions: What is the use of theory explanations and example descriptions in study texts? Do students use theories and examples to the same extent? Do they benefit from theories and examples in study texts when carrying out a task afterwards? These questions have a theoretical background in the Learning Paradox (Bereiter, 1985), which dates back to Meno's Paradox. According to the Learning Paradox, knowledge is necessary to acquire new knowledge. New knowledge always has a basis in existing knowledge. Plato addressed this paradox in his dialogue *Meno*, which he wrote in 380 B.C. Since then, this problem has received wide attention by both philosophers and psychologists as *Meno's Paradox*. Plato's solution has become known as the "recollection theory": "The soul, then, as being immortal, and having been born again many times, and having seen all things that exist, whether in this world or in the world below, has knowledge of them all; [...] for all enquiry and all learning is but recollection. (Jowett, 1996). Bereiter has interpreted Meno's Paradox as follows: "If one has tried 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." (Bereiter, 1985, p. 202). The recollection theory states that semantic knowledge is innate, and that learning is just a matter of recollecting existing knowledge. This point of view has modern advocates like Jackendoff (1992), who claims that language and knowledge both rest upon a finite set of innate primitives and combination principles, or Fodor (1981) who questions lexical compositionality and, therefore, holds that all concepts are innate.

In our research, we have attempted to collect empirical support for the position that experience is the basis for constructing new knowledge. That is, episodes of personal experience are stored in episodic memory (Tulving, 1992) and form the basis for inductive construction of new concepts. So, in previous studies we have attempted to show that concrete examples in study texts offer a route to students who want to understand the meaning of abstract concepts. We made use of the concept of Concrete Elaboration which was introduced by Vermunt (1992, 1998). Students differ in the extent to which they spontaneously generate examples when they encounter concepts and principles presented in a study text. Vermunt (1992) called this habit "concrete elaboration". The Concrete Elaboration scale of Vermunt's (1992) Inventory of Learning Styles has been found to be reasonably reliable (Prins, Busato, Hamaker, & Visser, 1996; Prins, Busato, Elshout, & Hamaker, 1998). In this study, evidence was sought for an aptitude-treatment interaction showing that students with a strong tendency to concrete elaboration prefer a deductive learning task, whereas students with a weak tendency to concrete elaboration benefit from an inductive learning task. The existence of this aptitude-treatment interaction was supposed to account for contradictory findings about the role of examples in expository texts. In some studies, examples were reported to distract the reader's attention from what the text was really about (Harp & Mayer, 1997; Wade, Schraw, Buxton, & Hayes, 1993). But examples were also shown to help the learner to understand abstract concepts (Sadoski, Goetz, & Fritz, 1993; Beck, McKeown, & Worthy, 1995).

Beishuizen, Stoutjesdijk, Spuijbroek, Bouwmeester, and Van der Geest (2002) replicated the study of Fong et al. (1986) and gave students two versions (a rule variant and an examples variant) of an expository text on the law of large numbers. With the help of the Inventory of Learning Styles of Vermunt (1992), Beishuizen et al. (2002) measured the amount to which participants reported the habit of relating information in a study text to everyday practice (Concrete Elaboration). They found that a high level of Concrete Elaboration enhanced the score on the posttest for the rule training group, but lowered the results for the examples training group. The students who scored low on the Concrete Elaboration scale displayed opposite results.

Beishuizen, Asscher, Prinsen, and Elshout-Mohr (2003) presented a study text from a first-year-course on Educational Psychology to 98 first-year-students. The text contained five different types of sections: (1) a main idea and two examples, (2) a main idea and five examples, (3) a main idea and one relevant and one irrelevant example, (4) two examples and no main idea, and (5) a main idea. They found that students who scored high on the Concrete Elaboration scale, scored better than students who scored low on the Concrete Elaboration scale on questions about sections without examples (type 3) or with an irrelevant example (type 5). Students who scored low on Concrete Elaboration, however, outperformed the high ‘concretisers’ on questions about sections with a main idea and two or five examples (type 1 and 2). As a result of their study, Beishuizen et al. (2003) suggested two interpretations of the Concrete Elaboration learning style: (1) The adaptation versus accumulation explanation, or (2) the deductive versus inductive learning explanation.

According to the adaptation versus accumulation explanation, high Concrete Elaboration students take their own knowledge as point of departure: On encountering a concept in a study text, they adapt existing knowledge by activating relevant examples, and integrate the new conceptual information with their existing knowledge. These students focus on abstract explanations of concepts, read one or two examples in the text and skip the rest of the examples. They may actually be led astray by too many examples. Low Concrete Elaboration students do not activate existing knowledge to the same extent and try to accumulate as much new information about concepts and examples as possible. They read every detail in the text, and understand the text better when it contains many examples.

The alternative deductive versus inductive learning explanation is inspired by Chi and VanLehn (1991) who showed that students, studying physics examples, generated two kinds of explanations. The first type of explanation indicated a deductive approach: instantiating a general principle with information in the example statement. The second type indicated an inductive approach: generalization and extension of the example statement. To put it differently, readers may reason either from general principles to examples by taking the principle as point of departure (the deductive approach), or from examples to general principles (the inductive approach) by abstracting general principles from examples. Students high on Concrete Elaboration would adopt the deductive approach whereas students low on Concrete Elaboration would prefer the inductive approach.

Problem definition

This study focused on deepening our insight into the role of concrete elaboration in the process of knowledge acquisition. In this way, we hoped to be able to better understand the way students construct knowledge by studying theory and example descriptions in expository texts. We hoped to find more empirical support for the interaction between the level of concrete elaboration and the theory- or example orientedness of expository texts, which was found in previous research (Beishuizen et al., 2002; Beishuizen et al., 2003). In this way we expected to be able to make a choice between the two explanations of the concept of concrete elaboration, the deductive versus inductive learning explanation on the one hand and the adaptation versus accumulation explanation on the other hand.

Research

In all experiments, the Concrete Elaboration scale of Vermunt’s (1992, 1998) Inventory of Learning Styles was administered. Participants were, in all experiments, 17 and 18 year-old students from various upper secondary schools in the neighbourhood of Amsterdam and Leiden.

In Chapter 2, we wanted to find out whether the learning style Concrete Elaboration, as measured by Vermunt's ILS, determines the number and distribution of comments during the reading- and thinking-aloud task, reflecting the process of studying expository texts. We compared the number and distribution of cognitive, affective and regulative comments in the protocols of low and high concretizing students. More specifically, we wanted to find out whether students with a high score on Concrete Elaboration display more deductive elaboration activities (i.e., generate more concrete comments) whilst studying theory paragraphs than whilst studying example paragraphs. We also wanted to test the expectation that students with a low score on Concrete Elaboration elaborate more in an inductive manner (i.e., generate more abstract comments) during study of example paragraphs, relative to theory paragraphs.

Method - We asked students to read and think aloud whilst studying a relatively difficult and a relative easy expository text. We designed a coding schema for interpreting the protocols and made distinction between four types of elaborations: conceptual elaborations (theory in the text – concept in the reader's memory), inductive elaborations (example in the text – concept in the reader's memory), deductive elaborations (theory in the text – episode of personal experience in the reader's memory), instance elaboration (example in the text – episode of personal experience in the reader's memory).
Results - We found empirical support for Vermunt's (1992) concept of concrete elaboration. Students, who were asked to read and think aloud during studying two expository texts, displayed a lot of deductive elaborations in the case of the difficult text. This was in particular the case with high CE students, as expected by the outcomes of the Concrete Elaboration scale. Apart from that, when studying the easy text, students also produced conceptual and instance elaborations, whereas inductive elaborations were very rare. It was concluded that the adaptation versus accumulation explanation of the concept of concrete elaboration received more support than the inductive versus deductive learning explanation. High CE students used their own knowledge as point of departure, whereas low CE students did not display any preference to particular chapter types as far as their style of processing is concerned. Neither did they show clear signs of inductive learning, which was predicted by the deductive versus inductive learning explanation.

In Chapter 3, we wanted to find out what the effect is of manipulating the number of example paragraphs and theory paragraphs in chapters of an expository text. Do students understand a chapter better when example paragraphs outnumber theory paragraphs or should the numbers be reversed? Secondly, we were interested in the question of what the effect is of manipulating the position of theory and example paragraphs in a chapter. Do students understand the chapter better when they first encounter example paragraphs and subsequently study theory paragraphs or should the order be reversed? The last question was whether the effects of number and position of theory and example paragraphs depend on the learning style of the student. Do high Concrete Elaboration (CE) students take theory paragraphs as point of departure whereas low Concrete Elaboration (CE) students try to grasp as much of the text as possible, irrespective of the type of paragraph they study?
Method - We applied a standard experimental design. First, we compared reading from text with reading from screen. In the second study we manipulated the chapters of an expository text by arranging theory and example paragraphs in four orders: one theory paragraph with four example paragraphs, four example paragraphs with one theory paragraph, one example paragraph with four theory paragraphs, and four theory paragraphs with one example paragraphs. We measured reading times per paragraph and performance on a comprehension posttest. In the third study, we fixed reading times and measured readability judgments and posttest performance.

Results - We concluded that reading from screen did not impede the process of text comprehension compared with reading from paper. There were no conspicuous differences in comprehension posttest scores between the two experimental groups. Therefore, we felt secure to continue our experiments with a computer supported reading environment in which students read texts from screen. The two subsequent studies showed that students in general, and low CE students in particular, spent more time on reading theory paragraphs, and also rated theory paragraphs as more difficult to read. However, no effects showed up on the comprehension posttest. The meaning of the concept of concrete elaboration has not been completely clarified. As far as high CE students are concerned, we find some support for the adaptation versus accumulation view, as Jonker, Beishuizen, and Veenman (submitted) concluded. High CE students spent more time on theory chapters than on example chapters and considered theory chapters more difficult to read than example chapters. Under the condition of free reading time, their performance scores suggested a higher level of understanding. Low CE students showed the same profile but this did not end up in better performance on a reading comprehension test.

In Chapter 4, we introduced freedom of choice of chapters and paragraphs in the study text. We wondered which type of paragraph of an expository text students prefer, theory paragraphs or example paragraphs, and which type of paragraph leads to better understanding, theory or example paragraphs. Furthermore, we were interested in the optimal design of a hypertext with respect to the level at which freedom of choice is provided, the level of choosing the order of chapters to study or the level of paragraph choice within chapters. It was important to find out which type of hypertext leads to better performance on a comprehension test. Of course, the distinction between low CE and high CE students came into focus again. The question was whether in a hypertext environment low CE and high CE student display different preferences for theory or example paragraphs, and differentially benefit from both types of paragraphs.

Method - We developed a hypertext reading environment in which students were free to choose theory paragraphs and example paragraphs within a chapter (first study) and, on top of that, the freedom of choice of chapters to subsequently study (second study). We assessed the choice of chapters and paragraphs within chapters, reading times per chapter, and performance on a comprehension posttest.

Results - We discovered a tendency among students to focus on theory paragraphs, a tendency which was displayed by both low CE students and high CE students. However, in the course of reading chapters, students became gradually familiar with the text and found that theory and example conveyed the same message about the underlying theoretical concept. Low CE students became aware of the opportunity to use example paragraphs as point of departure for studying the expository text. They were more and more inclined to focus on example paragraphs. This shift had a beneficial effect on their posttest performance, which raised and equalled the performance of low CE students relative to high CE students. This trend was more prominent under condition of limited freedom of choice. It was suggested that in a hypertext environment the freedom to choose chapters as well as paragraphs within chapters may cause an extra cognitive load, which impedes the primary process of reading and understanding according to one's preferred learning style. These findings caused a reconsideration of the adaptation versus accumulation view on concrete elaboration. It was suggested that the prevailing educational culture of focusing on theories at the expense of spending time and effort on studying examples might hamper low CE students in their preference for inductive elaboration. Therefore, changing the conditions may enable low CE students to develop their preferred strategy. Both studies in this experiment suggest that low CE students are more example oriented than theory oriented, which supports the induction versus deduction point of view.

In Chapter 5, we introduced a new task after text studying in place of a posttest: designing and conducting experiments. In this context of studying an expository text in order to prepare for an experiment we wondered to what extent understanding of the theoretical framework behind the simulation experiment is determined by studying the expository text and by conducting experiments. We were interested in differences between low CE and high CE students. Do high CE students differ from low CE students in their focus on type of paragraph (theory or example)? Do high CE students engage earlier in experimenting, and, hence, display shorter total reading times? Do high and low CE students benefit differentially from studying the text and conducting experiments on human memory?

Method - We designed and developed a learning environment for studying and experimenting (SEE), based on Wilhelm's (2001) design of FILE, a flexible inductive learning environment. The study environment resembled the hypertext environment designed in the previous experiment. Students were free to choice chapters and paragraphs within chapters. The experiment environment enabled students to determine the value of four discrete independent variables, predict the value of the outcome variable and run an experiment to see whether the prediction was confirmed. Students were able to switch between the study and experiment environment. However, initial studying had to be continued until at least one paragraph of each chapter had been read. Experimenting had to be continued until 15 experiments had been run. We assessed choice of chapters and paragraphs, reading times, all relevant characteristics of the experiments, time per experiment, and the number of variables varied between experiments (indicating the use of the Control of Variables Strategy). Students were tested on their understanding of the relationships between independent and dependent variables by asking them to complete an on-line theory interview.

Results - We concluded that both studying theory explanations and conducting experiments contributes to understanding the relationships between variables in a subject matter area. Students who focused on theories were clearly in a more favorable condition to run experiments than students focusing on examples. The quality of the process of conducting experiments, as measured by the time invested in every experiment and the number of variables varied at a time, was also a significant contributor to the variance in scores in the final comprehension test. Low and high CE students did not execute the task of conducting experiments with different strategies. So, it was concluded that the learning style of concrete elaboration has either limited significance, or does not come to expression in strategic behaviour as long as the student is not familiar with the task at hand. On the two contrasting pairs of explanation, induction versus deduction and adaptation versus accumulation, we argue as follows. The outcome that the learning style Concrete Elaboration, has a distinguishing impact on reading and not on experimenting, leads us to two possible explanations. Firstly, the lack of effect of the simulation part might be the result of novelty. Manipulating variables in order to test hypotheses is not something they are expected to be familiar with as opposed to reading for understanding. A second explanation, however, is that the adaptation versus accumulation approach is not able to explain all behaviour shown in the learning environment, and the deduction versus induction explanation comes out as the more parsimonious explanation of the two with respect to the whole task, that is, studying expository texts and carrying out online experiments. Results on the reading part of the learning environment alone do not favour adaptation versus accumulation either: No difference in reading time was found between high and low concretizers.

Conclusions

The results of the four experiments led to a reconsideration of the concept of concrete elaboration. The absence of inductive elaborations in the reading and thinking aloud task was interpreted in this way: That induction is primarily an internal and subconscious process, which is vital for constructing new concepts but does not lend itself to conscious control. Readers can use three pathways to process theories and examples in an expository text. The first one is conceptual elaboration, from concept in the text to concept in the reader's memory. The second one is deductive elaboration, from concept in the text to episode of personal experience in memory. The third one is from example in the text to episode of personal experience in memory. High CE students utilize the first and second pathways, while low CE students utilize the first and the third pathways. Construction of new concepts is the result of an internal process of induction, based on activated episodes of personal experience. Therefore, knowledge construction is considered an inductive process based on concrete experience. Therefore, it is assumed that the Learning Paradox can be resolved by asserting that induction of abstract concepts on the basis of activated episodes of personal experience is the basic mechanism of knowledge construction. This model explains most of the data, which were found in the four experiments.

Scientific Relevance

The study reported here started with the question as to whether the concept of concrete elaboration is useful in attempting to solve the Learning Paradox. The four experiments have produced valuable data on the basis of which a new model of concrete elaboration was proposed, which allows for various routes to understanding expository texts, corresponding with high and low values on the scale of concrete elaboration. This model should be tested in further empirical research. The inductive step is necessary to construct new knowledge. This inductive process does not appear to be very open to conscious control. We did not record traces of it during the collection reading and thinking aloud protocols in the study reported in Chapter 2. Rather, it is assumed that activating many relevant examples and episodes may start up the induction process. Existing concepts serve as a valuable filter in the process of activating episodes. Spreading of activation is an automatic, undirected process, and may, therefore, lead to activation of irrelevant episodes. This condition makes the process of knowledge construction for low CE students more hazardous. Because they do not make use of conceptual elaboration, they lack the power of existing concepts as supervisors of the activation process. If induction is not triggered, then the process is more a matter of accumulation of examples than a matter of knowledge construction by induction. Therefore, the alternative models presented above, the deductive versus inductive learning explanation and the adaptation versus accumulation explanation of the concept of concrete elaboration, may converge to one interpretation. An incomplete process of knowledge construction leads to accumulation of examples and episodes, as no new concepts are constructed if the process of induction fails. A complete process of knowledge construction leads to inductive learning because the activated episodes trigger the induction process and a new concept is the result of this process.

Educational Relevance

Two conclusions from this study are relevant for educational practice. The first one is that examples and episodes of personal experience are necessary and indispensable in the process of knowledge construction. Students should be given ample opportunity to construct knowledge by studying examples of the concepts to be learned. This supports the process of knowledge construction and allows students with various learning styles to choose different routes to understanding.

Secondly, the model shows that theoretical explanations can be guiding in the process of knowledge construction. Through the processes of conceptual and deductive elaboration, concepts can serve as a guiding source for activating relevant episodes of personal experience. Students should learn to use concepts as guidelines in order to use relevant experience to construct new concepts. In this way, both high and low Concrete Elaboration Students can learn to overcome the Learning Paradox.

References

Beck, I.L., McKeown, M.G., & Worthy, J. (1995). Giving a text voice can improve students' understanding. *Reading Research Quarterly, 30*, 2, 220-238.

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology, 73*(3), 291-316.

Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology*(72), 279-297.

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*(2), 201 - 226.

Chi, M. T. H., & VanLehn, K. A. (1991). The Content of Physics Self-Explanations. *Journal of the Learning Sciences, 1*(1), 69-105.

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The Effects of Statistical Training on Thinking About Everyday Problems. *Cognitive Psychology, 18*(3), 253-292.

Fodor, J.A. (1981). The current state of the innateness hypothesis. In J.A. Fodor (Ed.), *Representations*. Hassocks, Sussex: Harvester Press.

Ford, N. (2000). Cognitive styles and virtual environments. *Journal of the American Society for Information Science, 51*(6), 543-557.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Jowett, B. (1996). *Plato's Meno*. Available at http://classics.mit.edu/Plato/meno.html.

Jackendoff, R. (1992). *Languages of the mind. Essays on mental representation*. Cambridge, MA: The MIT Press.

Jonker, H. G., Beishuizen, J. J., & Veenman, M. V. J. (Submitted). Understanding an expository text – a process analysis. British Journal of Educational Psychology.

Prins, F. J., Busato, V. V., Elshout, J. J., & Hamaker, C. (1998). Een nieuwe bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen (ILS). A new contribution to the validation of a part of the Inventory of Learning Styles. *Pedagogische Studien, 75*(2), 73-93.

Prins, F. J., Busato, V. V., Hamaker, C., & Visser, K. H. (1996). Een bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen. A contribution to the validation of the (meta)cognitive part of the Learning Styles Inventory. *Pedagogische Studien, 73*(2), 108-122.

Sadoski, M., Goetz, E.T., & Fritz, J.B. (1993). Impact of concreteness on comprehensibility, interest, and memory for text: Implications for dual coding theory and text design. *Journal of Educational Psychology, 85*, 2, 291-304.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.). *Organization of memory* (pp. 382 - 405). New York: Academic Press.

Vermunt, J.D.H.M. (1992). *Leerstijlen en sturen van leerprocessen in het hoger onderwijs: naar procesgerichte instructie in zelfstandig denken* [Learning styles and guiding learning processes in higher education]. Amsterdam: Swets & Zeitlinger.

Vermunt, J.D.H.M. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology, 68*, 149-171.

Wade, S.E., Schraw, G., Buxton, W.M., & Hayes, M.T. (1993). Seduction of the strategic reader: effects of interest on strategies and recall. *Reading Research Quarterly, 28*, 2, 93-114.

Hoofdstuk 7. Samenvatting

Theoretische achtergrond

Dit onderzoek ving aan met een aantal eenvoudige vragen: wat is het nut van theorie en voorbeeldbeschrijvingen in studieteksten? Maken studenten in dezelfde mate gebruik van theoriebeschrijvingen en voorbeelden? Hebben ze baat bij theoriebeschrijvingen en voorbeelden in studieteksten wanneer ze vervolgens een taak moeten uitvoeren? Deze vragen hebben een theoretische basis in de leerparadox (Bereiter, 1985), die terug gaat op Meno’s paradox. Volgens de leerparadox is er evenveel kennis nodig om nieuwe kennis te verwerven. Nieuwe kennis heeft altijd een basis in al bestaande kennis. Plato behandelde deze paradox in zijn dialoog *Meno*, die hij schreef in 380 v.Chr. Sindsdien heeft dit probleem breed aandacht gekregen van filosofen en psychologen onder de noemer *Meno's Paradox*. Plato's oplossing is bekend geworden als de "herinneringstheorie": “Doordat de ziel onsterfelijk is en herhaaldelijk ontstaan is, doordat ze dingen hier op aarde en in Hades, en alles heeft gezien, is er niets dat ze niet heeft leren kennen; {…} omdat alle onderzoek en alle leren slechts herinnering is.” (Jowett, 1996). Bereiter interpreteerde Meno's Paradox als volgt: "Als we proberen de leerparadox te verklaren door mentale acties, uitgevoerd door de lerende, dan is het noodzakelijk om aan de lerende vooraf een mentale structuur toe te kennen die even geavanceerd en complex is als de mentale structuur die [met het leren] wordt nagestreefd." (Bereiter, 1985, p. 202). De herinneringstheorie zegt dat semantische kennis aangeboren is en dat leren een kwestie is van het herinneren van al bestaande kennis. Dit epistemologische uitgangspunt heeft aanhangers als Jackendoff (1992), die beweert dat taal en kennis beide rusten op een eindige set aangeboren categorieën (“primitives”) en combinatie principes, of Fodor (1981) die het bestaan van lexicale compositionaliteit in twijfel trekt en daarom zegt dat alle concepten aangeboren zijn.

In ons onderzoek hebben we geprobeerd om empirische ondersteuning te verzamelen voor de positie dat ervaring de basis is voorn het proces van kennisconstructie. Dat wil zeggen, episoden van persoonlijke ervaring zijn opgeslagen in het episodisch geheugen (Tulving, 1992) en vormen de basis voor inductieve constructie van nieuwe concepten. In eerdere studies hebben we daarom geprobeerd aan te tonen dat studenten, die de betekenis willen weten van abstracte begrippen, daartoe toegang kunnen krijgen door voorbeelden. We hebben gebruik gemaakt van het concept Concrete Elaboratie dat werd geïntroduceerd door Vermunt (1992, 1998). Studenten verschillen in de mate waarin ze spontaan voorbeelden genereren wanneer ze concepten en principes gepresenteerd krijgen in een studietekst. Vermunt (1992) noemde deze gewoonte "concrete elaboratie". De Concrete Elaboratie schaal van Vermunt's (1992) Inventaris Leerstijlen is redelijk betrouwbaar gebleken (Prins, Busato, Hamaker, & Visser, 1996; Prins, Busato, Elshout, & Hamaker, 1998). In dit onderzoek is naar evidentie gezocht voor een aptitude-treatment interaction, die laat zien dat studenten met een sterke tendentie tot concrete elaboratie een deductieve leertaak verkiezen, terwijl studenten met een zwakke tendentie tot concrete elaboratie meer baat hebben bij een inductieve leertaak. Het bestaan van de ATI zou de tegenstrijdige resultaten verklaren over de rol van voorbeelden in studieteksten. In aantal studies, werd geconcludeerd dat voorbeelden de aandacht van de lezer afleiden van de kern van de tekst (Harp & Mayer, 1997; Wade, Schraw, Buxton, & Hayes, 1993). Aan de andere kant is ook aangetoond dat voorbeelden de lerende kunnen helpen bij het begrijpen van abstracte concepten (Sadoski, Goetz, & Fritz, 1993; Beck, McKeown, & Worthy, 1995).

Beishuizen, Stoutjesdijk, Spuijbroek, Bouwmeester, and Van der Geest (2002) repliceerden de studie van Fong et al. (1986) en gaven studenten twee versies (een regel variant en een voorbeeld variant) van een studietekst over de wet van de grote getallen. Met behulp van de ILS van Vermunt (1992), maten Beishuizen et al. (2002) de mate waarin studenten de gewoonte rapporteerden dat ze informatie in een studietekst relateerden aan ervaring (Concrete Elaboratie). Ze vonden dat een hoog niveau van concrete elaboratie de score op de posttest voor de regel training groep verhoogden, maar voor de voorbeeld training groep juist verlaagden. De studenten die laag scoorden op concrete elaboratie lieten tegenovergestelde resultaten zien.

Beishuizen, Asscher, Prinsen, and Elshout-Mohr (2003) legden een studietekst van een eerstejaars cursus onderwijspsychologie voor aan 98 eerstejaars studenten. De tekst bevatte vijf verschillende typen hoofdstukken: (1) hoofdstukken met een hoofdidee en twee voorbeelden, (2) met een hoofdidee en vijf voorbeelden, (3) met een hoofdidee en een relevant en een irrelevant voorbeeld, (4) met twee voorbeelden zonder hoofdidee, and (5) hoofdstukken met alleen een hoofdidee. Gevonden werd dat studenten die hoog scoorden op Concreter Elaboratie schaal, hoger scoorden dan studenten die laag scoorden op de Concrete Elaboratie schaal, op vragen over hoofdstukken zonder voorbeelden (type 3) of met een irrelevant voorbeeld (type 5). Studenten die laag scoorden op Concrete Elaboratie presteerden beter dan hoogconcretiseerders op vragen over hoofdstukken met een hoofdidee en twee of vijf voorbeelden (type 1 en 2). Deze resultaten leidden Beishuizen et al. (2003) ertoe twee interpretaties te formuleren van de Concrete Elaboratie leerstijl : (1) de adaptatie versus accumulatie verklaring of (2) de deductief versus inductief leren explanation.

Volgens de adaptatie versus accumulatie verklaring, nemen hoog Concrete Elaboratie studenten hun eigen kennis als uitgangspunt: wanneer ze stuiten op een concept in de studietekst, adapteren ze bestaande kennis door het activeren van relevante voorbeelden, en integreren ze de nieuwe conceptuele informatie met hun bestaande kennis. Deze studenten richten zich op abstracte beschrijving van concepten, lezen een of twee voorbeelden in de tekst en slaan de rest van de voorbeelden over. Ze zouden zelfs in verwarring kunnen worden gebracht door teveel voorbeelden. Laag Concrete Elaboratie studenten activeren hun bestaande kennis niet in dezelfde mate en proberen zoveel mogelijk nieuwe informatie over concepten te verzamelen als mogelijk. Zij lezen alle details in de tekst en begrijpen de tekst beter als die veel voorbeelden bevat.

De alternatieve deductief versus inductief leren verklaring is geïnspireerd op Chi and VanLehn (1991). Zij lieten zien dat studenten die natuurkundige voorbeelden bestudeerden, twee typen verklaringen genereerden. Het eerste type verklaring wees op een inductieve benadering: Het benoemen van een algemeen principe met informatie uit het voorbeeld. Het tweede type wees op een inductieve benadering: generalisatie en uitbreiding van het voorbeeld. Anders gezegd, lezers kunnen redeneren vanuit algemene principes naar voorbeelden door het principe als uitgangspunt te nemen (deductieve benadering), of van voorbeelden naar een algemene principes (inductieve benadering) door algemene principes te abstraheren vanuit voorbeelden. Studenten hoog op Concrete Elaboratie zouden de deductieve benadering omarmen terwijl studenten laag op Concrete Elaboratie de inductieve benadering zouden verkiezen.

Probleem stelling

Deze studie richtte zich op het verdiepen van ons inzicht in de rol van concrete elaboratie in het proces van kennisconstructie door tekstbestudering. We hoopten op deze wijze beter te begrijpen op welke manier studenten kennis construeren door het bestuderen van theoriebeschrijvingen en voorbeelden in studieteksten. We hoopten meer empirische ondersteuning te vinden voor de interactie tussen het niveau van concrete elaboratie en de theorie- of voorbeeldgeoriënteerdheid van de studieteksten, die gevonden werd in eerdere studies (Beishuizen et al., 2002; Beishuizen et al., 2003). Op deze wijze verwachtten we in staat te zijn om een keuze te kunnen maken tussen de twee verklaringen van het concept concrete elaboratie, de deductieve versus inductieve leren verklaring aan de ene kant en aan de andere kant de adaptatie versus accumulatie verklaring.

Onderzoek

In alle experimenten werd de Concrete Elaboratie schaal van Vermunts (1992, 1998) ILS voorgelegd. De participanten waren steeds 17 of 18 jaar oud en afkomstig van verschillende VO scholen in de buurt van Amsterdam en Leiden.

In Hoofdstuk 2, wilden we nagaan of de leerstijl Concrete Elaboratie, zoals gemeten met Vermunt's ILS, het aantal en de verdeling van de uitingen bepaalt tijdens de hardop lees en denktaak, welke het proces van tekstbestudering reflecteert. We vergeleken het aantal en de verdeling van de cognitieve, affectieve, en regulatieve uitingen in de protocollen van laag en hoog concretiserende studenten. Meer in het bijzonder wilden we nagaan of studenten met een hoge score op Concrete Elaboratie meer deductieve elaboratie activiteiten laten zien (d.w.z., meer concrete uitingen genereren) tijdens het bestuderen van theorieparagrafen dan

wanneer ze voorbeeldparagrafen bestudeerden. Daarnaast wilden we onze verwachting toetsen dat studenten met een lage score op Concrete Elaboratie meer elaboreren op een inductieve wijze (d.w.z., meer abstracte uitingen genereren) tijdens het bestuderen van voorbeeldparagrafen ten opzichte van theorieparagrafen.
Methode- We vroegen studenten om hardop te lezen en hardop te denken, terwijl ze een relatief moeilijke tekst en een relatief makkelijke tekst bestudeerden. We ontwierpen een codeerschema voor het interpreteren van protocollen en maakten een onderscheid tussen vier verschillende typen elaboraties: conceptuele elaboraties (theorie in de tekst – concept in het geheugen van de lezer), inductieve elaboraties (voorbeeld in de tekst – concept in het geheugen van de lezer), deductieve elaboraties (theorie in de tekst – episode van persoonlijke ervaring in het geheugen van de lezer), en instantïele elaboraties (voorbeeld in de tekst – episode van persoonlijke ervaring in het geheugen van de lezer).
Resultaten – We hebben empirische ondersteuning gevonden voor Vermunts (1992) concept van concrete elaboratie. Studenten aan wie werd gevraagd hardop twee teksten te lezen en daarbij hardop na te denken, lieten veel deductieve elaboraties zien in het geval van de moeilijke tekst. Dit was in het bijzonder het geval met hoog CE studenten, in overeenstemming met wat we verwachtten op basis van de uitkomsten van concrete elaboratie. Daarnaast maakten studenten bij het lezen van de makkelijke tekst ook conceptuele and instantïele elaboraties, terwijl inductieve elaboraties zeldzaam waren. Geconcludeerd werd dat de adaptatie versus accumulatie verklaring van het concept concrete elaboratie meer ondersteuning vond dan de inductieve versus deductieve leren verklaring. Hoog CE studenten gebruikten hun eigen kennis als uitgangspunt, terwijl laag CE studenten geen voorkeur lieten zien voor een bepaald type hoofdstuk wat betreft hun verwerkingsstijl. Ze lieten geen duidelijke signalen van inductief leren zien, die was voorspeld door de deductief versus inductief leren benadering.

In Hoofdstuk 3 wilden we nagaan wat het effect is van het manipuleren van het aantal theorieparagrafen en voorbeeldparagrafen in de hoofdstukken van een studietekst. Begrijpen studenten een hoofdstuk beter als er meer voorbeeldparagrafen zijn dan theorieparagrafen, of andersom? Ten tweede waren we geïnteresseerd in de vraag wat het effect is van het manipuleren van de positie van theorie en voorbeeldparagrafen in een hoofdstuk. Begrijpen studenten de tekst beter als ze eerst voorbeeldparagrafen te zien krijgen en daarna theorieparagrafen, of andersom? De laatste vraag is of de effecten van aantal en positie van voorbeeld- en theorieparagrafen afhangen van de leerstijl van de student. Nemen hoog CE studenten theorieparagrafen als uitgangspunt, terwijl laag CE studenten proberen zoveel mogelijk van de tekst te lezen, onafhankelijk van het type paragraaf dat ze bestuderen?
Methode – We hebben een standaard experimenteel design toegepast. Eerst hebben we het bestuderen vanaf papier vergeleken met bestuderen vanaf het scherm. In het tweede experiment hebben we de hoofdstukken gemanipuleerd door de theorieparagrafen en de voorbeeldparagrafen in vier verschillende volgordes aan te

bieden: een theorie paragraaf met vier voorbeelden, vier voorbeelden met een theorieparagraaf, een voorbeeldparagraaf met vier theorieparagrafen, vier theorieparagrafen met een voorbeeldparagraaf. We hebben de leestijden per paragraaf en de begripstoetscores geregistreerd. In de derde studie hebben we de leestijden per paragraaf vastgezet en hebben we de leesbaarheidsbeoordelingen geregistreerd, alsmede de scores op de begripstoets.

Resultaten - We concludeerden dat lezen vanaf het scherm geen nadelig effect had op het process van tekstbegrip vergeleken met het lezen vanaf papier. Er waren geen duidelijke verschillen in begripsscores tussen de twee experimentele groepen. We voelden ons om die reden gerechtvaardigd onze experimenten te vervolgen met een computerondersteunde leesomgeving waarin de studenten tekst vanaf het scherm lezen. De twee studies lieten zien dat studenten in het algemeen, en laag concretiseerders in het bijzonder, meer tijd besteedden aan het lezen van theorieparagrafen en ook de leesbaarheid van de theorieparagrafen moeilijker beoordeelden. Er traden echter geen effecten op bij de begripstoets. De betekenis van het concept concrete elaboratie is niet volledig opgehelderd. Wat betreft de hoog concretiseerders, vinden we enige ondersteuning voor de adaptatie versus accumulatie visie, zoals Jonker, Beishuizen, and Veenman (submitted) concludeerden. Hoog CE studenten besteedden meer tijd aan theorieparagrafen dan aan voorbeeldparagrafen en beschouwden theorieparagrafen als moeilijker te lezen dan voorbeeldparagrafen. Onder de conditie dat de leestijden vrij waren leek er gezien hun scores sprake te zijn van een hoger niveau van begrip. Laag CE studenten lieten hetzelfde profiel zien maar dit resulteerde niet in een beter resultaat op de begripstoets.

In hoofdstuk 4 introduceerden we keuzevrijheid van hoofdstukken en paragrafen in de studietekst. We vroegen ons af aan welk type paragrafen in een studietekst studenten de voorkeur geven, theorieparagrafen of voorbeeldparagrafen, en welke typen hoofdstukken leiden tot een beter begrip, theorieparagrafen of voorbeeldparagrafen. Verder waren we geïnteresseerd in het optimale design van een hypertekst met betrekking tot het niveau waarop het voorziet in keuzevrijheid, op het niveau van het kiezen van de volgorde van te bestuderen hoofdstukken, of op het niveau van paragraafkeuzes binnen hoofdstukken. Het was belangrijk na te gaan welk type hypertekst leidt tot een beter leerresultaat. Natuurlijk hebben we ook het onderscheid laag versus hoog concretiseerders betrokken bij deze studies. De vraag was of hoog en laag concretiseerders van elkaar verschilden met betrekking tot hun voorkeuren voor voorbeeldparagrafen en theorieparagrafen in een hypertekst omgeving, en of ze op een verschillende manier baat hadden bij beide typen paragrafen.

Methode – We hebben een hypertext leesomgeving ontwikkeld waarin studenten voorbeeldparagrafen en theorieparagrafen vrij konden kiezen binnen hoofdstukken (eerste experiment), en daar boverop de vrijheid op het niveau van hoofdstukken (tweede experiment). We hebben de keuze van paragrafen binnen hoofdstukken geregistreerd, leestijden per hoofdstuk en prestatie op de begripstoets.

Resultaten - We ontdekten een tendentie onder de studenten om zich te richten op theorieparagrafen, een tendentie die we zowel bij laag als bij hoog concretiseerders aantroffen. Echter, in de loop van het lezen van de hoofdstukken, werden studenten geleidelijk aan steeds bekender met de tekst en ervoeren dat theorieparagrafen en voorbeeldparagrafen dezelfde boodschap over het onderliggende concept in zich borgen. Laag CE studenten werden zich bewust van de mogelijkheid om voorbeeldparagrafen te gebruiken als uitgangspunt om een tekst te bestuderen. Ze richtten zich meer en meer op voorbeeldparagrafen. Deze verschuiving van aandacht had een positief effect op hun score op de begripstoets, die toenam tot het niveau van de hoog concretiseerders. Deze trend was prominenter aanwezig onder de conditie van beperkte keuzevrijheid. Het lijkt zo te zijn dat in een hypertekst omgeving, zowel de vrijheid om hoofdstukken te kiezen als paragrafen te kiezen binnen hoofdstukken, leidt tot cognitieve belasting. Deze cognitieve belasting heeft een negatief effect op het primaire proces van lezen en begrijpen volgens de leerstijl van je voorkeur. Deze resultaten hebben geleid tot een heroverweging van de adaptatie versus accumulatie visie op concrete elaboratie. Het lijkt erop dat de heersende onderwijscultuur, die zich richt op theorie ten koste gaat van tijd en inspanning aan voorbeelden. Dit zou laag CE studenten kunnen belemmeren in hun voorkeur voor inductieve elaboraties. Het veranderen van die omstandigheden zou laag CE studenten in staat tellen om hun geprefereerde leerstijl tot ontwikkeling te laten komen. Beide studies in dit experiment leken aan te tonen dat laag CE studenten meer voorbeeld- dan theorie georiënteerd zijn, hetgeen de inductie versus deductie visie ondersteunt.

In Hoofdstuk 5 introduceerden we, in plaats van een begripstoets, een nieuwe taak in aansluiting op het bestuderend lezen: bedenken en uitvoeren van experimenten in plaats van een begripstoets. We vroegen ons af in welke mate het begrijpen van het onderliggende theoretische framewerk bepaald wordt door het lezen van voorbeelden en theorieparagrafen, in de context van de voorbereiding op het on-line experimenten bedenken en uitvoeren. We waren geïnteresseerd in de verschillen tussen hoog en lag CE studenten. Verschillen hoog CE studenten van laag CE studenten wat betreft hun gerichtheid op type hoofdstuk (theorie of voorbeeld)? Beginnen hoog CE studenten eerder aan experimenteren, en laten ze bijgevolg kortere leestijden zien? Hebben hoog en laag CE studenten op een andere manier baat bij het studeren van tekst en het uitvoeren van experimenten over het menselijk geheugen?

Methode - We ontwierpen en ontwikkelden een leeromgeving om in te lezen en in te experimenteren (SEE), gebaseerd op Wilhelm's (2001) ontwerp van FILE (flexible inductive learning environment). De studeeromgeving leek op de omgeving uit het vorige hoofdstuk. Studenten waren vrij om hoofdstukken te kiezen en ook om paragrafen te kiezen binnen de hoofdstukken. De experimenteeromgeving stelden studenten in staat om de waarde te bepalen van vijf discrete variabelen, voorspellen van de uitkomstvariabele en een experiment uitvoeren om te zien of de voorspelling wordt bevestigd. Studenten hadden de mogelijkheid om tussen de studeeromgeving en de experimenteeromgeving te schakelen, maar pas nadat aan een minimum leeseis was voldaan. Van ieder hoofdstuk moest minimaal een paragraaf gelezen zijn. Voor het experimenteren moest aan de minimumeis van 15 experimenten voldaan zijn om toegang te krijgen tot het laatste theorie interview.

Wij hebben de keuze van hoofdstukken en paragrafen geregistreerd, evenals de leestijden en alle relevante karakteristieken van de experimenten, tijd per experiment, het aantal variabelen dat gevarieerd werd bij twee opeenvolgende experimenten, een maat voor het gebruik van de CVS strategie. Studenten werden getest op hun begrip van de samenhang tussen de afhankelijke en de onafhankelijke variabelen door hen te vragen een theorie interview in te vullen.

Resultaten - We concludeerden dat zowel het bestuderen van theorieparagrafen als het doen van experimenten bijdraagt aan een begrip van relaties tussen variabelen binnen een bepaald domein. Studenten die zich richtten op theorieparagrafen waren duidelijk in een betere positie om experimenten uit te voeren dan studenten die zich op voorbeelden hadden gericht. De kwaliteit van het proces van het experimenten uitvoeren, gemeten met de tijd per experiment en het aantal variabelen dat gevarieerd werd per keer, was ook een belangrijke bijdrage aan de variatie in scores op het laatste theorie interview. Laag en hoog concretiseerders voerden de taak van het experimenten uitvoeren niet met andere strategieën uit.

Er werd geconcludeerd dat de leerstijl concrete elaboratie ofwel weinig betekenis heeft, of niet tot uiting komt in strategisch gedrag zolang de student niet bekend is met de onderhavige taak.

Wat betreft de twee contrasterende paren verklaringen redeneren we als volgt. Het resultaat dat de leerstijl concrete elaboratie een onderscheidend effect heeft op het lezen en niet op het experimenteren leidt tot twee mogelijke verklaringen. In de eerste plaats kan het gebrek aan effect bij het experimenteren veroorzaakt zijn door nieuwheid van de taak. Het manipuleren van variabelen om hypotheses te toetsen is niet iets waarvan we kunnen verwachten dat deze studenten er bekend mee zijn. Een tweede verklaring is echter dat de adaptatie versus accumulatie benadering niet in staat is om al het gedrag te verklaren en dat de deductief versus inductief leren benadering wat betreft parsimonie beter uit de bus komt met betrekking tot de hele taak (lezen en experimenteren). De resultaten op het leesgedeelte alleen zijn de adaptatie versus accumulatie benadering ook al niet gunstig gezind. Er werd geen verschil gevonden in leestijden tussen hoog en laag CE studenten.

Conclusies

De resultaten van de vier experimenten leidden tot een heroverweging van het concept concrete elaboratie. De afwezigheid van inductieve elaboraties in the hardopdenk taak is geïnterpreteerd als dat inductie primair een intern en onbewust proces is, dat essentieel is voor het construeren van nieuwe concepten, maar zich niet leent voor bewuste processen bij lezen. Lezers kunnen drie verschillende trajecten afleggen om theorie en voorbeelden te verwerken in een studietekst. Het eerste is conceptuele elaboratie, van concept in de tekst naar concept in het geheugen van de lezer. Het tweede is deductieve elaboratie, van concept in de tekst naar episode van persoonlijke ervaring. Het derde is van voorbeeld in de tekst naar episode van persoonlijke ervaring in het geheugen. Hoog CE studenten gebruiken het eerste en tweede pad, terwijl laag CE studenten het eerste en het derde gebruiken. Constructie van nieuwe concepten is het resultaat van interne inductie, gebaseerd op geactiveerde episodes van persoonlijke ervaring. Kennisconstructie kan daarom worden gezien als een inductief proces vanuit concrete ervaring. We kunnen daarom aannemen dat de leerparadox verdwijnt met de claim dat inductie van abstracte concepten, op basis van geactiveerde episodes in het geheugen, gezien kan worden als het basale mechanisme van kennisconstructie. Dit model verklaart veel van de resultaten die de vier experimenten hebben opgeleverd.

Wetenschappelijke relevantie

Het onderzoek begon met de vraag of het concept concrete elaboratie zinnig is om te gebruiken om de leerparadox op te lossen. De vier experimenten hebben waardevol materiaal opgeleverd, op basis waarvan een nieuw model is voorgesteld, die verschillende trajecten tot begrip van studietekst toelaat, in overeenstemming met hoge en lage waarden van concrete elaboratie. Dit model moet worden getest met nieuw empirisch onderzoek. De inductieve stap is noodzakelijk voor kennisconstructie. Het inductieve proces lijkt niet erg open te zijn voor bewuste controle. We hebben geen sporen geregistreerd in de hardopdenk protocollen in de studie die in hoofdstuk 2 gerapporteerd is. Het ligt meer voor de hand dat het activeren van veel voorbeelden en episodes het inductieproces op gang kan brengen. Bestaande concepten dienen als een waardevol filter van het activeren van episodes. Spreiding van activatie is een automatisch ongericht proces, en kan er daarom toe leiden dat ook irrelevante episodes worden geactiveerd. Deze conditie maakt het proces van kennisconstructie gevaarlijk voor laag CE studenten. Omdat ze geen gebruik van conceptuele elaboratie, missen ze de kracht van bestaande concepten als begeleiders van het activatieproces. Als inductie niet wordt op gang wordt gebracht, dan wordt kennisconstructie meer een kwestie van het verzamelen van voorbeelden dan van kennis constructie door inductie. De twee contrasterende modellen convergeren naar daarmee naar één model. Een incompleet proces van kennisconstructie leidt tot de opstapeling van voorbeelden en episodes, omdat er geen nieuwe concepten worden geconstrueerd als het proces van inductie faalt. Een compleet proces van kennisconstructie leidt tot inductief leren omdat de geactiveerde episodes het inductie leren op gang brengen en resulteert in een nieuw concept.

Onderwijskundige relevantie

Twee conclusies uit deze studie zijn relevant voor de onderwijspraktijk. De eerste is dat voorbeelden en episodes van persoonlik ervaring noodzakelijk en onmisbaar zijn in het proces van kennisconstructie. Studenten zouden voldoende mogelijkheid moeten krijgen om nieuwe kennis te construeren door het bestuderen van voorbeelden van de te leren concepten. Dit ondersteunt het proces van kennisconstructie en stelt studenten met verschillende leerstijlen in staat om verschillende trajecten te kiezen die tot begrip leiden.

Ten tweede, laat het model zien dat theoretische beschrijvingen leidend kunnen zijn in het proces van kennisconstructie. Via het proces van conceptuele en deductieve elaboratie , kunnen concepten fungeren als leidende bron voor het activeren van relevante episodes van persoonlijke ervaring. Studenten zouden moeten leren concepten te gebruiken als richtlijnen om relevante ervaring aan te roepen en nieuwe concepten te construeren. Op deze manier kunnen zowel hoog als laag CE studenten leren de leerparadox te overstijgen.

Referenties

Beck, I.L., McKeown, M.G., & Worthy, J. (1995). Giving a text voice can improve students' understanding. *Reading Research Quarterly, 30*, 2, 220-238.

Beishuizen, J. J., Asscher, J. J., Prinsen, F. R., & Elshout-Mohr, M. (2003). Presence and place of main ideas and examples in study texts. *British Journal of Educational Psychology, 73*(3), 291-316.

Beishuizen, J. J., Stoutjesdijk, E. T., Spuijbroek, S., Bouwmeester, S., & Van der Geest, H. (2002). Understanding abstract expository texts. *British Journal of Educational Psychology*(72), 279-297.

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*(2), 201 - 226.

Chi, M. T. H., & VanLehn, K. A. (1991). The Content of Physics Self-Explanations. *Journal of the Learning Sciences, 1*(1), 69-105.

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The Effects of Statistical Training on Thinking About Everyday Problems. *Cognitive Psychology, 18*(3), 253-292.

Fodor, J.A. (1981). The current state of the innateness hypothesis. In J.A. Fodor (Ed.), *Representations*. Hassocks, Sussex: Harvester Press.

Ford, N. (2000). Cognitive styles and virtual environments. *Journal of the American Society for Information Science, 51*(6), 543-557.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Jowett, B. (1996). *Plato's Meno*. Available at http://classics.mit.edu/Plato/meno.html.

Jackendoff, R. (1992). *Languages of the mind. Essays on mental representation*. Cambridge, MA: The MIT Press.

Jonker, H. G., Beishuizen, J. J., & Veenman, M. V. J. (Submitted). Understanding an expository text – aprocess analysis. British Journal of Educational Psychology.

Prins, F. J., Busato, V. V., Elshout, J. J., & Hamaker, C. (1998). Een nieuwe bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen (ILS). A new contribution to the validation of a part of the Inventory of Learning Styles. *Pedagogische Studien, 75*(2), 73-93.

Prins, F. J., Busato, V. V., Hamaker, C., & Visser, K. H. (1996). Een bijdrage tot de validatie van het (meta)cognitieve deel van de Inventaris Leerstijlen. A contribution to the validation of the (meta)cognitive part of the Learning Styles Inventory. *Pedagogische Studien, 73*(2), 108-122.

Sadoski, M., Goetz, E.T., & Fritz, J.B. (1993). Impact of concreteness on comprehensibility, interest, and memory for text: implications for dual coding theory and text design. *Journal of Educational Psychology, 85*, 2, 291-304.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.). *Organization of memory* (pp. 382 - 405). New York: Academic Press.

Appendix (Concrete Elaboration subscale)

CE Items 1, 3, 5, 7, 9 and filler statements 2, 4, 6, 8, 10.

Name:………………….
Surname:………………..
Sex: Male/Female Age:…..

Below are 10 statements about learning for school examinations. Read them carefully. Choose the alternative that suits you best. Encircle the figure. This is about your learning habits. There are no right or wrong answers. Everybody have their own learning habits and ideas on learning! Do not skip questions. Try to avoid alternative 3 (‘neutral or don’t know’) if possible.

1 While I am studying, I think of matters that I know out of my own personal experience, and that have to do with the course content.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

2 I make a list of the most important facts and learn that list by heart.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

3 If possible, I try to understand everyday events in the light of what I have learnt in my study.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

4 I try to relate new course contents to what I know already of the subject.Ik probeer nieuwe leerstof in verband te brengen met wat ik al weet over het onderwerp.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

5 I devote my attention especially to the practically useful parts of the subject.Ik besteed vooral aandacht aan de praktisch bruikbare onderdelen van een vak.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

6 I devote my attention, whilst studying, especially to facts, concepts and definitions.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

7 With help of what I learn in class, I think of solutions for practical problems.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

8 I compare the most important ideas of the different chapters to one another.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

9 I use what I learn in class also for activities outside the study.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always

10 When I am studying, I think of examples related to course content.

1	**2**	**3**	**4**	**5**
seldom or never	sometimes	neutral or don’t know	often	(nearly) always