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Reading Science Textbooks: The Role of Metacognition in Reading Comprehension

Lavinia Haiduc [1] and Ciascai Liliana[2]

[1] Babes-Bolyai University, Cluj-Napoca, Romania
[2] Department of Educational Sciences, Babes-Bolyai University, Cluj-Napoca, Romania

Abstract. Reading comprehension has been increasingly studied by researchers in the field of educational psychology, who showed that metacognitive strategies are an essential predictor of reading comprehension. Given the important role of metacognition in reading comprehension, the present study investigates what metacognitive strategies are used by students in reading texts from science textbooks. A group of 137 pupils enrolled in ninth grade at three public schools was involved in the research. Participants completed a scale generated from the The Junior Metacognitive Awareness Inventory and answered to three open questions. Data analysis suggests that pupils generally use various metacognitive strategies in reading science texts. Nevertheless, they reported a number of essential issues involved in reading comprehension in science. The results of the present study are discussed in relation with implications for future research and educational practice.

Keywords: reading comprehension, metacognitive strategies, 9th grade students, Science.

1. Introduction

Much of science teaching is guided by the constructivist perspective on learning, which promotes the active engagement of pupils in the learning process and the connection of prior knowledge with new knowledge. Based on the constructivist approach of learning, many theorists acknowledged the role of hands-on activities in teaching and learning science. In addition to the strong promotion of hands-on activities in teaching science, the role of science textbooks has considerably diminished (Koch, 2001). Nevertheless, research indicates that students with effective reading strategies learn better that those with ineffective reading strategies (Yore, Craig, & Maguire, 1998; Barton & Jordan, 2001; Cartier, 2000, Doly 2006). Furthermore, effective science reading is a significant predictor of science performance (O'Reilly & McNamara, 2007).

Text-based learning and reading comprehension have been increasingly studied by researchers in the field of educational psychology. Reading comprehension can be defined as the aim of understanding the meaning of written words, sentences and texts at different levels: lexical, syntactic, semantic and pragmatic (Aarnoutse & Leeuwe, 1998). Besides understanding the literal linguistic content of a text, learning form text involves comprehension at two essential levels: textbase level and situation level (van Dijk and Kintsch, 1983). Semantic information is acquired and coded into a coherent set of propositions during the textbase level. During the second comprehension level, the situation level, the prior knowledge on a given topic is integrated with the information encountered in the text, facilitating its storage in the long-term memory. In order to successfully cover these two levels of text comprehension, readers have to actively engage in the reading process (Ariasi & Mason, 2011). Therefore, reading comprehension involves an active and dynamic process of identifying various relationships in a text (Yang, 2007).

[1] *Email:* lavinia_haiduc@yahoo.com
[2] *Email:* liliana.ciascai@ubbcluj.ro

Reading comprehension can be influenced by the interaction of various factors, like the content of the text, the reader's goals and prior knowledge and cognitive and metacognitive processes. The common difficulties in text comprehension arise from the hardship of decoding the text or from poor metacognitive skills (Hall, 2004). Yore et al. (1998) showed that generally elementary and middle school students have superficial knowledge about science reading strategies, emphasizing the essential role of metacognitive training in reading strategies. Metacognitive strategies can be organized at three different hierarchical levels: the highest level, the intermediate level and the lowest level (Meijer, Veenman & Houte-Wolters, 2006). The highest level comprises planning, monitoring and evaluation. At the second level we encounter selection of information, recapitulation and reflection on the learning process. The last level can be characterized by confirming or rejecting former inferences based on subsequent text. In the literature there are some recommendations regarding the reading strategies that students should underpin while reading science textbooks. According to these recommendations, students should clarify the purpose of reading and establish adequate reading strategies; activate and use prior relevant knowledge; focus attention to important ideas; evaluate the content for compatibility with prior knowledge; self-questioning to verify comprehension and draw and test inferences or make corrections when failures in comprehension are detected (Barton & Jordan, 2001). Reading comprehension has been shown to be correlated with a number of metacognitive strategies such as activating background knowledge, summarizing text, generating questions, clarifying word meaning and predicting what might come next in the text (Spörer, Brunstein & Kieschke, 2009; Cartier, 2004).

Given the importance of metacognition in reading comprehension, the present study investigates what metacognitive strategies are used by 9th grade pupils in reading texts from science textbooks. Furthermore, because various issues were reported in the literature regarding the factors which hinder reading comprehension, a second aim of our study was to identify these challenging factors in the case of science reading comprehension.

2. Methodology

2.1. Participants

The participants were 137 pupils enrolled in the ninth grade at three public schools in large metropolitan school districts. The requirements for inclusion were the consent form for study participation. Participants' mean age was 15.67 years, with an age range of 14-17 years. The sample comprised 43 females (31.4%) and 94 males (68.6%).

2.2. Measures and procedure

Measures were obtained from a self-administered scale with 17 items and 3 open questions. The scale used in the present study was adapted after the Metacognitive Awareness Inventory (Schraw & Sperling-Dennison, 1994) and measured what metacognitive strategies pupils use when reading science textbooks. The scale aimed to assess the following metacognitive strategies: predicting and verifying, previewing, purpose setting, self-questioning, drawing from background knowledge and summarizing. Participants were asked to encircle their answer on a five point scale (from 1 to 5). The research instrument also comprises three open questions which aimed to identify what difficulties pupils encounter when reading texts from science textbooks. The Alpha Cronbach of the scale was 0.83. The instrument was administered on one group session in school classes. Participants were asked to complete the Jr. MAI taking into account their experience in Science, specifically in Physics, Chemistry and Biology. Participants were asked to complete the instrument taking into account their experience in Science, more specifically in Physics, Chemistry and Biology. Participation was voluntary and anonymous, and had no effect on students' academic standing.

3. Results

Data analysis indicates that students who participated in the present study use their metacognitive skills when reading texts from Science textbooks. The means for the items which measure metacognitive regulation range between 2.64 and 4.09. The most common metacognitve strategy used by students is "reading again a specific paragraph" (mean = 4.09, standard deviation = 1.22). However, the following metacognitive strategies are likewise widely used: "*I re-read the text to better understand it*" (m = 3.84, std.

= 1.37), "*I revise the difficult information*" (m = 3.76, std. = 1.29), "*I consciously focus my attention on relevant information*" (m = 3.72, std. = 1.30), "*I focus my attention on understanding the meaning of the new information I read*" (m = 3.65, std. = 1.24), "*I evaluate if I've understood the information*" (m = 3.53, std = 1.21) and "*I slow down reading when I encounter important information*" (m = 3.51, std. = 1.37). The least used strategy is "*Before I start learning a new lesson, I ask questions regarding the material I have to learn*", with a mean of 2.64 and a standard deviation of 1.49.

The inter-items correlations indicate that generally the 9th grade students use more than two specific metacognitve strategies in reading. For instance, those students who are prone to think about the text they have to read before opening the textbook also focus their attention on the relevant information in the text. Table 1, presented below, illustrates the inter-items correlations for metacognitve strategies used in reading comprehension in science.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	1	.32**	.40**	.32**	.26**	.28**	.31**	.22*	.22*	.15	.21*	.03	.10	.22*	.04	.20*	.25**
2	.32**	1	.44**	.23**	.32**	.17*	.34**	.09	.11	.04	.28**	.00	.21*	.17	.09	.37**	.31**
3	.40**	.44**	1	.39**	.26**	.26**	.37**	.31**	.23**	.28**	.28**	.08	.27**	.23**	.20*	.24**	.41**
4	.32**	.23**	.39**	1	.40**	.27**	.28**	.19*	.07	.29**	.25**	.16	.36**	.17*	.20*	.15	.22**
5	.26**	.32**	.26**	.40**	1	.35**	.11	.07	.10	.08	.27**	.00	.29**	.11	.11	.13	.11
6	.28**	.17*	.26**	.27**	.35**	1	.42**	.27**	.11	.22**	.27**	.04	.32**	.29**	.23**	.29**	.27**
7	.31**	.34**	.37**	.28**	.11	.42**	1	.30**	.32**	.25**	.29**	.11	.20*	.26**	.27**	.36**	.49**
8	.22*	.09	.31**	.19*	.07	.27**	.30**	1	.27**	.17*	.03	.00	.05	.15	.24**	.23**	.34**
9	.22*	.11	.23**	.07	10	.11	.32**	.27**	1	.19*	.06	.01	.12	.14	.21*	.25**	.31**
10	.15	.04	.28**	.29**	.08	.22**	.25**	.17*	.19*	1	.19*	.11	.21*	.27**	.38**	.22*	.28**
11	.21*	.28**	.28**	.25**	.27**	.27**	.29**	.03	.06	.19*	1	.14	.35**	.23**	.29**	.36**	.29**
12	.03	.00	.08	.16	.00	.04	.11	.00	.01	.11	.14	1	.12	.23**	.03	.03	.11
13	.10	.21*	.27**	.36**	.29**	.32**	.20*	.05	.12	.21*	.35**	.12	1	.36**	.26**	.38**	.24**
14	.22*	.17	.23**	.17*	.11	.29**	.26**	.15	.14	.27**	.23**	.23**	.36**	1	.29**	.35**	.24**
15	.04	.09	.20*	.20*	.11	.23**	.27**	.24**	.21*	.38**	.29**	.03	.26**	.29**	1	.34**	.34**
16	.20*	.37**	.24**	.15	.13	.29**	.36**	.23**	.25**	.22*	.36**	.03	.38**	.35**	.34**	1	.52**
17	.25**	.31**	.41**	.22**	.11	.27**	.49**	.34**	.31**	.28**	.29**	.11	.24**	.24**	.34**	.52**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table1. Inter-items correlations

1. I think to what I have to study before I open the textbook.
2. I slow down reading when I encounter important information.
3. I consciously focus my attention on relevant information.
4. I regularly revise in order to better understand the relevant information.
5. Before I start learning a new lesson, I ask questions regarding the material I have to learn.
6. After I finish reading a lesson, I summarize what I have read.
7. When I do not understand something, I stop and I read again the paragraph.
8. I know what strategies I use when I learn.
9. I focus my attention on understanding the meaning of the new information I read.

10.	I use my own examples in order to better understand information.
11.	I evaluate if I have understood the information.
12.	I use diagrams to better understand a text.
13.	I make use of the text organization for better understanding a text.
14.	I assess to what extent what I've already know connects to the new information I read.
15.	I split the text in small steps.
16.	I revise the difficult information. I re-read the text to better understand it.

The analysis of pupils' open answers are structured in three categories: difficulties encounter in reading texts from science textbooks, methods used for selecting the relevant information and the approach preferred by students in learning science. The first category of answers revealed that 9th grade pupils face a variety of issues in reading texts from science textbooks. Accordingly, one issue encounter by students is the high number of definitions and theories which need to be memorized. In addition to this issue, students also mentioned that there are a high number of difficult concepts they do not understand. The analysis of the second category of answers disclosed the following strategies used for selecting the relevant information from a science text: selecting and learning formulas and highlighting the relevant information. Regarding the last category of open answers, the analysis revealed that 9th grade students would rather like the teacher to inform them about what is relevant in a given text than to discover the relevant information by themselves.

4. Discussions and conclusion

The main goal of the present study was to investigate what metacognitve strategies are used by 9th grade pupils in reading texts from science textbooks. Furthermore, because various issues were reported in the literature regarding the factors that hinder reading comprehension, a second aim of our study was to identify these challenging factors in the case of science reading comprehension. The results indicate that the 9th grade pupils who participated in the present study generally use various metacognitive strategies in reading science texts. Nevertheless, the participants acknowledged that the difficult concepts encounter in science texts hinder their efforts for successful learning. Thereby, there might be a gap between pupils' reading level and the readability of Science textbooks. Furthermore, the difficulty of understanding science concepts might be related with the lack of relevant prior knowledge in science. The results of the present study are in line with the previous research which shows that students have reported an overwhelmingly large number of new vocabulary terms in textbooks (Guzzeti, Hynd, Skeels & Williams,1995; Ogens 1991) and that main ideas are often presented with much nonessential information and technical terminology, thus causing readers difficulty in identifying the most important concepts. Other analyses have revealed that science texts reserve only a small amount of space to discuss the way in which science relates to real-world experience of pupils (Schroeder et al., 2009).

An important predictor of text comprehension is the frequency and the time spent in reading (Taylor, Frye & Maruyam, 1990; Guthrie, Wigfield, Metsala & Cox, 2009). However, these two variables are differently correlated with reading comprehension, according to the readers' proficiency in a specific subject. Accordingly, for low proficiency learners, the correlations between the time spent in reading and reading comprehension are non-significant. From another standpoint, in the case of high-proficiency learners, the correlations between the time spent in reading and reading comprehension are moderate and significant (e.g. Pichette, 2006). The results of the present study are in agreement with the data presented above, the participants indicating re-reading as an important strategy used for understanding the relevant information in a science text.

Focused attention and slowdown of reading are two additional strategies, besides re-reading, used by the participants in the present study. Cormier (2006) emphasizes that pupils are aware of the need to focus attention on the relevant information but that this cognitive awareness is unspecified regarding its object and content. Cormier (2006) and Vianin (2011) highlighted the importance of awareness for activating specific cognitive processes, in order to understand a text.

Another strategy underlined by the 9th grade pupils is the evaluation of information comprehension. The metacognitive strategies mentioned above address mainly the reading approach. Nevertheless, the strategies which help in preparing the reading process are mentioned by a small percentage of participants. Therefore, there might be a need for training pupils in each aspect concerned with reading and reading comprehension.

Considering the results of the present study, we can draw up a set of recommendations for policymakers and specifically for teachers whose students face difficulties in reading science texts. There might be a need for taking into account the reading level of pupils and the readability of the Science textbooks. Regarding policymakers, significant criteria for evaluating the readability of Science textbooks should be used. Furthermore, the development of science textbooks should be based upon empirical research, in order to be adequate for the reading level of pupils and not only for the curricula outlines

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