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Metacognitive strategies that Romanian pupils use when reading science textbooks

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Abstract— **The aim of the present study is to investigate the metacognitive strategies that pupils use when reading science textbooks. The sample of this study was composed of 171 nine-grade pupils from four schools in Romania, who completed a scale with 21 items. The quantitative analysis of the data suggests that pupils have average metacognitive skills for effectively using the science textbooks. It is recommended that if pupils are to fully benefit from the information presented in science textbooks, teachers have to help them use this resource in more constructive ways, and policy makers should focus more on the readability of science textbooks.**

Keywords-metacognitive strategies, reading, science textbooks, 9th grade pupils, textbooks' readability.

I. INTRODUCTION

Science education research and interventions have focused on the role of hands-on and problem solving activities until 1980s [1], thus marginalizing the role of science texts and science reading. However, nowadays researchers and science teachers agree that effective science reading is an essential prerequisite for better learning in this field, reading comprehension being a significant predictor of science performance [2]. Students need to have effective reading strategies to learn successfully [3]. Research showed that one of the most cost-effective ways to improve academic performance of learners is to improve the quality of textbooks [4]. Access to and availability of textbooks is a significant predictor of academic achievement [5], some researchers identifying a positive link between student achievement and textbooks [6] [7]. Reading proficiency in science is important because, as Barton and Jordan concluded, "reading science text and textbooks requires the same critical thinking, analysis, and active engagement as performing hands-on science activities" [8].

Verspoor [9] considers that textbook is one of the most important resources used by teachers in the teaching process and The Third International Mathematics and Science Study (TIMMS) reported that mathematics teachers rely on textbooks in delivering science topics. In America for instance, more than 90% of the secondary school teachers use textbooks for teaching science and for assigning homework [10]. Further, other researchers showed that textbooks have been regarded by many teachers as the main resource used for teaching and learning [11].

Textbooks represent an important resource for instruction and often teachers have the freedom to decide which textbook is more appropriate for teaching the topics presented in the national curricula. On the other hand, textbook authors also have freedom to develop their own approach to the delivery of national curricula and thus textbooks represent a considerable diversity. In Romania, teachers have the freedom to choose the textbook they consider to be appropriate for pupils in their class. Thus teachers take decisions regarding the role allocated to the textbook in the learning process: which textbooks to use, where and when to use textbooks.

However, besides the science textbooks, learners have to use effective reading strategies for better learning in the field. Students need to have effective reading strategies to learn successfully [3]. Yore et al. [3] showed that elementary and middle school pupils have surface knowledge about science reading, science text, and science reading strategies. Thus, they argue that metacognitive comprehension strategies, such as planning, monitoring, and regulation of global meaning making should be addressed in reading research in science education [12].

Metacognitive strategies can be organized on different levels, such as: a) planning, monitoring and evaluation (at the highest level); b) selection of information, recapitulation, and reflection on the learning process (at the intermediate level); c) inferring the meaning of an unknown word from its context, confirming or rejecting former inferences based on subsequent text [13].

Brown and Palincstar [14] consider there are several reading strategies that pupils should underpin when teaching science textbooks: 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. Lin [15] emphasized that the main metacognitive strategies that pupils should use are "error detecting, effort and attention allocating, self-questioning, self-explanation, constructing visual representations, activating prior knowledge, re-reading difficult text sections, and going back to revise" (p. 25). All metacognitive strategies deal with self-awareness, self-regulation and self reflection before, during and after cognitive endeavors [16] [17] [18].

In Romania, the textbooks for primary and secondary school are free and teachers can choose from three different textbooks. At the high school level there is a high variety of textbooks for a field of study (6-7 textbooks), but the prices for purchasing the textbooks are quite high. Thus science textbooks are generally absent from rural and poor urban classes. For this reason science textbooks are relatively little used by science teachers. But there are more reasons for little use of science textbooks by teachers, such as: a) the teachers' and pupils' parent opinion that pupils are send to school in order learn from the teacher, not from the textbook; b) the practice of some teachers to use exactly the same content presented in the textbook, thus the teacher becoming a "talking book"; c) discontent related to the content and structure of textbooks [19].

The objective of this study is to explore how science textbooks are used by pupils, and more specifically what metacognitive strategies pupils use when reading science textbooks. We consider that knowing how pupils use textbooks is essential, taking into consideration that much investment is put into the provision of science textbooks. Also, is essential to know how pupils prepare in science disciplines using textbooks, if we want to provide the best services and resources for pupils in learning science, and thus to improve the present resources or to teach pupils to use them in an efficient way.

II. Methodology

A. Participants

Data were obtained through questionnaires with 9th grade pupils from four cities in Romania. A number of 171 pupils from 4 high schools participated in this study, as follow: 64 pupils from Zalau, 35 from Campia Turzii, 11 from Cluj-Napoca and 61 from Targu Mures. Participants age ranged between 15-16 years, with a mean age of 15,69 (SD = 0,53). The sample contained 59 females and 112 males. The ethnic background of pupils is similar, most of them being Romanians, 3 being Hungarians and one being Slovak. Figure 1 shows pupils distribution by sex, in percentages.

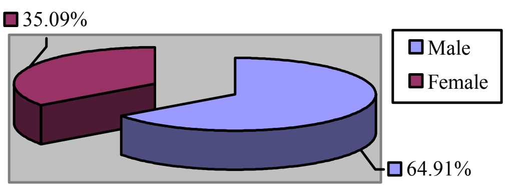

Figure 1. Pupils' distribution by sex

B. Measures

Measures were obtained from a self-administered scale with 21 items, and 3 open questions. The scale comprises a socio-demographic section in which pupils were asked to provide information regarding their age, school profile, city, sex, ethnicity, parents' profession, their last marks at Physics, Chemistry and Biology and the title and authors of the textbooks for each of the three disciplines mentioned above. The scale aimed to assess pupils' metacognitive strategies when reading science textbooks and the open questions aimed to identify the main difficulties that pupils encounter when reading science textbooks. Participants were asked to choose the proper answer on a five point scale, ranging from 1 to 5. High scores indicate a high and effective use of science textbooks by pupils during the learning process, while low scores indicate a low and ineffective use of science textbooks by pupils. Our instrument assessed pupils' use of metacognitive strategies used before, during and after reading a text, such as: predicting and verifying, previewing, purpose setting, self-questioning, drawing from background knowledge and summarizing. In table 1 we provide information regarding the reliability of the scale used in the present study.

TABLE I. RELIABILITY STATISTICS

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	No of Items
.876	.879	21

C. Procedure

The questionnaire was sent through electronic mail and a teacher from each school in the sample was designed to present the instrument to pupils, and to return it by the postal service. Participation was voluntary and anonymous, and had no effect on students' academic standing. The participants were recruited from schools with technical and services profiles. We choose those schools that collaborated before, in different inquiries. From the school level were chosen all the pupils from the nine grade level, who were asked to complete the scale in classroom.

III. Results

In tables 2, 3 and 4 we present the means and standard deviations for the variables involved in the analysis, organized by the main dimensions of the scale: strategies used before reading, strategies used during reading and strategies used after reading. As can be seen in there tables, the means for the variable under investigation range between 2.68 and 4.04. A high mean indicates effective reading strategies, while a low mean indicates ineffective reading strategies when using science textbooks.

TABLE II. STRATEGIES BEFORE READING

Strategies before reading	N	Mean	Std. Deviation
I think to what I have to study before I open the textbook	167	3.44	1.45
I know what teacher expects from me to learn from the textbook	167	3.15	1.34
Before I start learning a new lesson, I ask questions regarding the material I have to learn	171	2.68	1.49

Metacognitive strategies used before reading are essential, since the use of these types of strategies help pupils to focus their attention on what they have to learn, and on exploring what they already know about the subject they will read about. As can be seen in table 2, the mean for the strategy "I ask questions about the material that pupils I have to read" is 2.68. This means that pupils moderately use this metacognitive reading strategy when studying science.

TABLE III. STRATEGIES DURING READING

Strategies during reading	N	Mean	Std. Deviation
I slow down learning when I encounter important information	170	3.61	1.36
I can identify the relevant information when reading from the Physics textbook	170	3.31	1.42
I can identify the relevant information when reading from the Chemistry textbook	171	3.10	1.35
I can identify the relevant information when reading from the Biology textbook	171	3.43	1.42
I consciously focus my attention on relevant information	171	3.72	1.32
When I do not understand something, I stop and I read the paragraph again	171	4.04	1.28
I know what strategies I use when I read texts from science textbooks	169	3.37	1.25
I focus my attention on understanding the meaning of the new information I read	168	3.62	1.27
I use my own examples in order to better understand the information I read	169	3.47	1.31
I split the text in small steps	170	3.17	1.40
I revise the difficult information	169	3.75	1.35
I read again the text, in order to better understand it	168	3.82	1.40
I use diagrams to better understand the text I read	168	2.80	1.51
I make use of the text organization for better understanding the text I read	168	2.98	1.43

Data presented in table 3 illustrate that pupils generally use metacognitive strategies when reading science textbooks. The most used strategies are reading again the text they did not understand, and focusing attention on understanding the meaning of the new information. The last strategy decreases the chance of memorizing a text without understanding it. These strategies help pupils to engage in a durable and transferable learning, making them active learners. Further, metacognitive strategies used during reading a text increase the active cognitive processing of that text and, as a consequence, the reading comprehension and science achievement [20].

TABLE IV. STRATEGIES AFTER READING

Strategies after reading	N	Mean	Std. Deviation
I regularly revise the text in order to better understand the relevant information	169	2.95	1.29
After I finish reading a lesson, I summarize what I read	171	3.27	1.48
I assess to what extent what I already know connects to the new information I read	166	3.20	1.30
I evaluate if I understood the information	168	3.51	1.27

Metacognitive strategies used after reading and learning new information from a text are essential for retaining and using that new information for longer periods, and in new contexts. From the metacognitive strategies employed by pupils, two of them are essential for a quality learning process: summarizing and connecting the new information with prior knowledge.

Even if pupils use moderately metacognitive strategies when reading science textbooks, they encounter some difficulties, which make studying science quite difficult. These difficulties are illustrated in Figure 2.

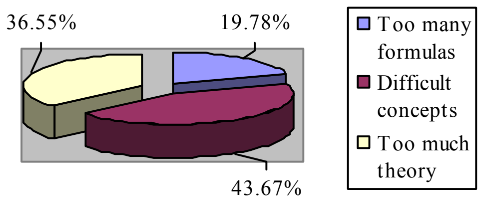

Figure 2. The difficulties of pupils in reading science textbooks

As can be seen in figure 2 presented above, 9th grade pupils consider that science textbooks contain too many formulas and too much theory. Moreover, the concepts presented in science textbooks are too difficult, even when pupils use metacognitive reading strategies. The difficulty of the concepts was mentioned as the main problem encounter when reading science textbooks, by the highest percent of the participants, more specifically by 43.67% of the participants

IV. Discussion and Conclusions

Concern has been expressed that information in textbooks is not always accurate, and that there might be a gap between the reading level of pupils and the readability of textbooks [21]. Koch [22] has found that material that require an unusually high level of effort from the student will make student frustrated and anger, and might negatively affect pupil's attitude toward learning. Further, Chamberlain and Crane's research [23] suggests that most pupils have difficulty with science textbooks, thus the readability of science textbooks is a major concern.

Even if textbooks are generally used by the 9th grade participants in the present investigation, we consider that teachers and policy makers should focus more on the readability of science textbooks. We consider that if a given textbook has an appropriate readability level, students are more likely to read texts before going to class, and that teacher will be able to cover the material in less time and, as a consequence, focus on additional materials or projects.

Moreover, we consider that in order for textbooks to be useful and effective resources for pupils, teachers have to focus on developing pupils' critical thinking skills. This is essential because pupils should learn to question the authors' assumptions and the accuracy of the information provided in textbooks. Even if textbooks might be considered "authorized knowledge", pupils could be encouraged to ask questions while they read, to seek answers within the text and to identify different sources for seeking additional information. In this way, teachers facilitate the involvement of pupils as active readers in the learning process.

In conclusion, we consider that teachers should evaluate the reading level of pupils and the readability of the Science textbooks, in order to choose the appropriate textbooks for a given class of pupils. Further, policy makers should develop science textbooks having as the base the results of empirical research. In this way, they can assure that textbooks are appropriate for the reading level of pupils, and not only for the curricula outlines.

Even of the present study show that 9^{th} grade pupils can use effective metacognitive strategies when reading science textbooks, the results should be replicated for generalizing the results. Further, the results of the present study were obtained using a self-administered questionnaire developed by the researchers, and this involves a reduced control for the variables measured during the investigation.

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