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Original research paper

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THE USE OF LEARNING STRATEGIES IN E-LEARNING AND ACHIEVEMENT

Abstract

Using strategies in learning is one of the main predictors of achievement. In learning from digital texts, it is even more important because, compared to learning from printed material, it gives the learner more opportunities to look for different options and at the same time lose focus while learning. Therefore, the aim of our study was to find out: 1) what learning strategies students use during learning from digital text and how often they use them; 2) how the use of these strategies is related to achievement; and 3) the differences in the use of learning strategies and in achievement between boys and girls. 443 students (219 boys and 224 girls) from grade 9 of primary school participated in the study. The students learned about the perception of colors with the help of an e-learning unit. They had the choice to make notes for learning. The notes were collected after learning and analyzed according to the learning strategy used (rehearsing, elaboration, and organization). Their knowledge on the subject was assessed by a pre- and post-test consisting of 5 open and 8 multiple-choice questions covering the learning material. Results showed that students who took notes scored higher on the post-test than those who did not take notes (M_1 = 8.78, SE_1 = 0.19, M_2 = 6.18, SE_2 = 0.34; $t(438)$ = 6.78, $p < 0.001$). Analysis of students' notes showed that rehearsing strategies (f = 555) were used more frequently than elaboration (f = 415) and organization strategies (f = 357). The correlation between deep strategies (elaboration and organization) and achievement on post-test (r = 0.44, $p < 0.001$) was significantly higher ($z(326)$ = 4.52, $p < 0.001$) than the correlation between surface strategies and achievement (r = 0.17, $p < 0.01$). Compared to boys, girls took longer notes (M_1 = 77,67, SE_1 = 5,19, M_2 = 123.34, SE_2 = 5.67, $t(327)$ = 5.75, $p < 0.001$), used more strategies (M_1 = 3,02, $SE1$ = 0.18, M_2 = 4.79, SE_2 = 0.21, $t(327)$ = 6.12, $p < 0.001$), and achieved a higher score on the post-test (M_1 = 7.45, SE_1 = 0.27, M_2 = 8.73, $SE2$ = 0.23, $t(440)$ = 3.68, $p < 0.001$). The results showed the importance of prompting the making of notes and use of higher order learning skills for successful learning in e-environment.

Keywords: digital text, learning strategies, note-taking, students, achievement

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Introduction

Different digital sources are increasingly used in the school environment. In the last 10 years, e-learning sources such as digital textbooks, interactive videos and various learning platforms for adaptive learning are being rapidly developed (Novak et al., 2018). Therefore, the aim of our study was to investigate how students approach learning when learning from digital text.

The use e-sources in learning provides relatively easy and quick access to the vast amount of information, involves a high degree of interactivity and adaptability, and offers the possibility of instant feedback on a person's learning progress (Embong et al., 2012). However, the main feature is its multimodality (Cope & Kalantzis, 2010), the possibility that different perceptual and cognitive systems are involved in the learning process. Research in this area indicates that the multimodal nature of learning, the integration of images and words, is more efficient than learning from simple text or traditional textbooks (Mayer, 2009).

Although learning from digital texts has many advantages, it also has some disadvantages (Kwan, 2001). Effective navigation through digital sources is more difficult than on paper (Wolf, 2008), especially with longer texts (Jabr, 2013). The so-called "tempting details" (i.e., interesting but irrelevant words or images (Grosman, 2011)) may draw the reader's attention in an undesirable direction. Therefore, it requires more attention and effort from the reader than learning from a textbook (Liu, 2005). Compared to paper sources, readers report higher levels of stress and fatigue (Wästund et al., 2005), and approach reading less seriously when using digital sources (Ackerman & Goldsmith, 2011), which potentially leads to lower achievement (Mangen, et al., 2013).

To overcome these disadvantages and achieve their learning goals when learning with digital sources, students need even more self-regulation than when learning with paper texts. They need to put in more effort, suppress distractions, direct their attention, and use different learning strategies. Thus, self-regulated learning involves cognitive, metacognitive, affective, and motivational processes. In our study, we focus on one part of self-regulation, namely the cognitive processes, and investigate the cognitive learning strategies students use when learning from digital text.

Cognitive learning theory with multimedia (Mayer, 2014) assumes that learning is optimal when the design of the multimedia unit considers the cognitive capacity of the students. It must minimize the processing of irrelevant information and maximize the important and generative processing of information. However, for optimal learning outcomes and overcoming disadvantages resulting from the complexity of digital sources, students need to activate two aspects of cognitive self-regulatory processes. On the one hand, they need to use cognitive processes for processing information and encoding it into long-term memory in a way that can be used later. They need various learning strategies to select, organize and integrate information meaningfully into their cognitive structure (Mayer &

Wittrock, 2006). On the other hand, students also need the metacognitive aspect of self-regulation, which is the awareness of their goals, cognitive processes, and their needs in the learning situation.

As Subramanian (2018, p. 864) states, "strategies are secret algorithms of learning" and they represent executive processes of selecting, adapting, and using different learning skills. The strategies a student uses depend on his learning goal, which can be memorization of learning content or its comprehension. For memorization, rehearsing an information in its original form may be sufficient; for meaningful learning, other strategies are necessary. Weinsten & Mayer (1986) proposed three cognitive strategies, namely, rehearsal, elaboration, and organization strategies. All these groups of strategies have a basic and a complex form. We have used their conceptualization of cognitive learning strategies as a framework for analysis in our research. Rehearsal strategies are used to store information in long-term memory without changing or transforming it. Elaboration strategies are used to integrate existing prior knowledge with new information. Organization strategies are used to sort and cluster the information based on the relationship that these new concepts have with other concepts. Elaboration and organization strategies are higher order strategies often associated with deep and meaningful learning (Mayer, 1996).

Research on the use of learning strategies showed moderate (for rehearsing strategies) to high (for elaboration and organization strategies) effects on student achievement (Hattie, 2009). One of the ways to use different strategies during learning is notetaking, which involves repeating, selecting, and integrating incoming information, thus promoting deep learning. Notetaking has been found to be a very effective approach to improve student achievement (Haghverdi et al., 2010; Subramanian, 2018). In addition to the effect on achievement, it is also important for research purposes as it is direct evidence of students' strategy use. Therefore, we decided to use notes taken during learning as a direct measure of students' cognitive learning strategies.

We were also interested in gender differences in learning from digital text. The differences between boys and girls were found in terms of learning strategies, mainly in favour of girls. Girls use all types of strategies more frequently, during and after reading (Ghiasvand, 2010; Pečjak & Košir, 2003), they show higher awareness of the importance of using cognitive learning strategies, especially elaboration, organization, and active forms of rehearsal (Tomec et al., 2006). They also write more relevant information in their notes, write faster (Reddington et al., 2015), and are better at summarizing the text they read (Kolić-Vehovec et al., 2008).

To summarize, in our study we focused on three research questions: 1) Which and how many cognitive learning strategies students used in learning from digital text? 2) What is the relationship between the strategies they used during learning and achievement? 3) Are there differences in the use of learning strategies in terms of their quantity and quality between boys and girls.

Method

Participants

The sample of our study consisted of 443 students (224 girls and 219 boys) of 9th grade from 15 primary schools in Slovenia. Their average age was 14.38 years (*SD* = 0.40). Out of 443 students, 329 students took notes.

Instruments and materials

E-unit on perception of colors: Students learned from interactive learning unit in the field of natural science. E-unit was based on a unit from digital textbook with the title "Chemistry 9: textbook for chemistry in the 9th grade of primary school" (Jamšek et al., 2014). The topic of unit is the perception of colors. E-unit was composed of 1073 words, with another 226 words in glossary, which was available for additional explanation of main concepts (electromagnetic waves, photons etc.). It was divided into six chapters: 1. Eyes and the perception of colors, 2. How a human being is perceiving colors, 3. Why are carrots well-recommended for good sight, 4. The solubility of β carotene, 5. How can we use the knowledge about the solubility in different solvents in real life, and 6. Vitamin A for healthy living. The chapters contained text, pictures (21), schemes (5), 1 video clip and 1 choice task, which served as a quick check-up of the understanding of the watched video clip. Interactive parts of e-unit were therefore: 1. Video clip showing solubility of β carotene in water and in hexane, which the students could stop and play according to their needs, 2. Choice task below video clip, which checked student's understanding of the video clip, and 3. The important terms they could click on to get more information from the additional glossary. Students progressed through the text by clicking to open individual chapters, video or terms in the glossary.

Perception of colors achievement test: Students' knowledge was assessed with the same achievement test (Boh et al., 2019) before and after learning. It contained five open ended questions (i.e., "Describe how the process of perceiving visual stimuli takes place?") and eight multiple-choice questions with five possible answers, the last of which was always "I don't know". Students' responses to open-ended questions were scored on a three-point scale: no answer or incorrect answer (0), partially correct answer (1) and correct answer (2). Two independent assessors evaluated all answers and resolved all the existing discrepancies. Cronbach's α reliability coefficient for post-test was 0,77.

The process of data collection

Data was collected as part of the project Effectiveness of different types of scaffolding in self-regulated e-learning (project number: J5-9437). Students for whom their parents gave informed consent participated in the study. They learned about colour perception individually on their own computers during their chemistry class. The researcher gave instructions and told the students that they could take notes while learning. The students were given a sheet of paper to take notes on. When they were done learning, the notes were collected for further analysis. Students completed the pre-test about two weeks before learning from e-unit and took the post-test immediately after learning. The amount of time students invested in learning ranged from 5 to 55 minutes ($M = 30.75$, $SD = 8.60$).

Data analysis and coding scheme

Notes were then coded using a coding scheme developed based on Weinstein and Mayer's (1986) cognitive strategy model, which consists of three groups of strategies: rehearsal, elaboration, and organization. Each strategy has two subcategories, basic and complex. Following Marton and Säljö (1976), who suggested that rehearsal leads to surface learning, while the use of elaboration and organization leads to deep learning, we also formed two supercategories. Elaboration and organization strategies therefore represent supercategory of deep learning strategies (strategies for constructing and integrating knowledge), while rehearsal strategies represent supercategory of surface learning strategies (strategies for acquisition and memorization - lower order strategies).

Therefore, the final coding scheme consists of six categories on the first level of coding: 1) basic rehearsal strategies (writing down single concepts/words, "telegraphic" input), 2) complex rehearsal strategies (word-for-word transcription of a sentence or sentences), 3) basic elaboration strategies (forming a sentence linking two or more different concepts, associations, mnemonics, and answering questions), 4) complex elaboration strategies (paraphrasing, summarizing, analogies, and turning words into drawings), 5) basic organization strategies (grouping information based on common features but without a hierarchy), and 6) complex organization strategies (grouping information based on common features into a hierarchy or sequence of events); three categories on the second level of coding: 1) rehearsal strategies, 2) elaboration strategies and 3) organizational strategies; and two categories on the third level of coding: 1) surface strategies and 2) deep strategies.

Each strategy switch (change from one strategy to another) was coded as a separate strategy. Two coders independently coded 1/3 of the notes. The initial level of agreement between coders was 90.61% (Krippendorff's $\alpha = 0.87$). Although it was high enough, the coders discussed the discrepancies and additionally adjusted certain coding criteria. After each coder coded the notes according to the agreed-upon criteria, the level of agreement was 98.46% (Krippendorff's $\alpha = 0.98$). We also counted the number of words used in each note as a measure of the notes' length.

For statistical analysis, we used SPSS. After reviewing the data, we deleted missing values (less than 5%). We also checked all variables for normal distribution and calculated descriptive statistics. For the analysis of differences, we used the *t*-test when the assumptions for its use were met. When the assumptions were not met, the Mann-Whitney *U* test was used. For the analysis of differences in the decision to take notes between genders, we used the χ2 test. We calculated Pearson's correlation coefficient (*r*) for the associations between learning achievement and different learning strategies and used Fisher's Z-transformation to determine the significance of the correlation differences.

Results

Learning strategies

Table 1 presents means, standard deviations, and frequencies of cognitive learning strategies at all coding levels. Out of 443 students, 329 took notes. The mean length of the notes was 103.76 words ($SD = 74.70$), and the average number of strategies used was 4.03 ($SD = 2.74$).

Table 1
Frequencies, average frequencies and standard deviations of cognitive learning strategies used by students.

Strategies			*f*	*M*	*SD*
Surface					
	Rehearsal		555	1.50	1.00
		Basic rehearsal	63	.21	.44
		Complex rehearsal	492	1.29	.95
Deep			772	1.52	1.61
	Elaboration		415	1.05	1.16
		Basic elaboration	59	.11	.34
		Complex elaboration	356	.94	1.09
	Organization		357	.47	.84
		Basic organization	195	.25	.56
		Complex organization	162	.22	.55

Students used deep strategies ($f = 772$) more often than surface strategies, with rehearsal ($f = 555$) being used separately more often compared to elaboration ($f = 415$) and organization ($f = 357$) strategies.

Correlations between learning strategies and achievement

On average, students scored 2.62 points ($SD = 2.09$) on the pre-test and 8.10 points ($SD = 3.69$) on the post-test. Students who took notes had significantly higher scores on the post-test ($M_1 = 8.78$, $SE_1 = 0.19$) than those who did not take notes ($M_2 = 6.18$, $SE_2 = 0.34$; $t(438) = 6.78$, $p < 0.001$).

The correlation between the number of strategies used and post-test score was 0.41 ($p < 0.001$), while the correlation between the length of notes and post-test score was slightly lower ($r = 0.25$, $p < 0.001$). The correlation between note length and number of strategies was 0.56, $p < 0.001$.

Table 2

Pearson's correlations and partial correlations between used cognitive learning strategies and post-test score

Strategies			Post-test score *r*	partial *r*
Surface				
	Rehearsal		.17**	.18**
		Basic rehearsal	.08	.05
		Complex rehearsal	.14**	.16**
Deep			.44***	.39***
	Elaboration		.28***	.24***
		Basic elaboration	.10	.07
		Complex elaboration	.28***	.24***
	Organization		.41***	.38***
		Basic organization	.32***	.28***
		Complex organization	.35***	.33***

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Partial correlations were controlled for the effect prior knowledge (pre-test score).

As shown in Table 2, there are no significant differences between the ordinary and partial correlation. The largest difference between the ordinary and partial correlation was found for the deep strategies although this difference was small and insignificant ($z(323) = 0.76$, $p > 0.05$). Therefore, we decided to use the absolute score (post-test score) instead of the relative one (post-test score controlled for the effect of prior knowledge) for interpretation.

The correlation between the deep strategies and the post-test score ($r = 0.44$, $p < 0.001$) was statistically significantly higher ($z(326) = 4.52$, $p < 0.001$) than the correlation between the surface strategies and the post-test ($r = 0.17$, $p < 0.01$). For surface strategies, only a low positve correlation was found between complex rehearsal and the post-test ($r = 0.14$, $p < 0.01$), whereas for deep strategies, moderate positive correlations were found between complex elaboration and the post-test ($r = 0.28$, $p < 0.001$), basic organization and the post-test ($r = 0.32$, $p < 0.001$), and complex organization and the post-test ($r = 0.35$, $p < 0.001$).

The differences between boys and girls

The X^2 test showed that there was a significant relationship between students' gender and the decision to take notes (X^2 (1, $N = 443$) = 23.29, $p = 0.000$). Girls ($N = 188$, 84.38%) were more likely to choose to take notes than boys ($N = 141$, 64.38%).

The *t*-test showed that girls took longer notes ($M_1 = 77{,}67$, $SE_1 = 5{,}19$, $M_2 = 123.34$, $SE_2 = 5.67$, $t(327) = 5.75$, $p < 0.001$), on average used more strategies ($M_1 = 3{,}02$, $SE1 = 0.18$, $M_2 = 4.79$, $SE_2 = 0.21$, $t(327) = 6.12$, $p < 0.001$), and scored higher on the post-test ($M_1 = 7.45$, $SE_1 = 0.27$, $M_2 = 8.73$, $SE2 = 0.23$, $t(440) = 3.68$, $p < 0.001$.

Table 3

Results of t-test for gender differences in average use of cognitive learning strategies at each level of coding

Strategies			girls *M*	girls *SE*	boys *M*	boys *SE*	*t*(327)
Surface							
	Rehearsal		1.82	.10	1.50	.08	2.44*
		Basic rehearsal	.18	.03	.21	.04	-.73
		Complex rehearsal	1.65	.09	1.29	.08	2.80**
Deep			2.97	.16	1.52	.14	6.55***
	Elaboration		1.42	.10	1.05	.10	2.64**
		Basic elaboration	.23	.04	.11	.03	2.28*
		Complex elaboration	1.19	.08	.94	.09	2.05*
	Organization		1.55	.11	.47	.07	7.67***
		Basic organization	.85	.07	.25	.05	6.34***
		Complex organization	.70	.07	.22	.05	5.59***

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, $df = 327$. $N_{girls} = 188$, $N_{boys} = 141$.

All the significant differences between boys and girls in learning strategy use were in favour of girls (Table 3). These differences are somewhat smaller for surface strategies than for deep strategies.

Discussion

The use of learning strategies is an important mediator between the learner, his environment, and his learning achievement. In learning with digital texts, the use of learning strategies is even more important as digital environment can be disorienting compared to paper material (Jabr, 2013), learners are less serious about learning (Ackerman & Goldsmith, 2011), which means less concentration (Liu, 2005; Wästund et al., 2005) and a less successful learning process (Mangen et. al., 2013). Our study focuses on the use of learning strategies in learning with digital text.

The first research question of our study was which and how many strategies students use when learning from digital text. In the school context, an important strategy for achieving academic goals is note-taking (Haghverdi et al., 2010). Our findings showed that most students chose to take notes, indicating that they are aware of the usefulness of notetaking, including while learning with digital text. Students who took notes performed better on the tests than those who did not take notes, confirming the importance of notetaking in learning in the digital environment. By taking notes, students process the new information in a way that best suits their needs and existing cognitive structure (Ward & Tatsukawa, 2003), which can lead to better understanding of the new content and higher test scores (Haghverdi et al., 2010; Subramanian, 2018).

Students used rehearsal strategies more often than elaboration and organization strategies in their notes. The reason for this may be that the content they were learning about was completely new to them, so they focused primarily on memorizing the basic concepts. They used fewer organizational strategies, although when they did use them, these strategies often covered a wider range of content and therefore took more time than the memorization strategies. This may explain their lower numbers. Nevertheless, students used more deep strategies (organization and elaboration together) than surface strategies.

Our second research question was to determine the degree of correlation between the use of learning strategies and learning achievement. We found a moderate correlation between the number of strategies used and post-test score. Students who used more strategies were more likely to achieve higher test scores. This result is consistent with other research on the connection between the use of learning strategies and achievement (Hattie, 2009; Semperio, 2019; Subramanian, 2018). The correlation between note length and test score was weak, while the correlation between note length and number of strategies used was strong. This clearly shows that the longer the notes were, the more likely they were to contain more learning strategies, which is also reported by other authors (e.g., Peverly et al., 2007). However, longer notes do not necessarily mean higher achievement. For example, many students in our study made large organizational structures in their notes, which covered the most important concepts from e-unit. These, when counting the number of words to the determine the length of notes, weren't long, and indeed often included smaller number of strategies. Yet it's precisely the organizational strategies that were associated with the higher achievement the most. There were also student's notes that were especially long, yet mostly included rehearsal strategies, which had the weakest relationship with achievement.

Studies showed that organizing and elaborating strategies are higher-order strategies that are often associated with deep, meaningful learning (Mayer, 1996). We also found a higher association between deep strategies and test scores than between surface strategies and test scores. Most strategies were positively related to test scores, apart from Basic Elaboration and Basic Rehearsal. These might be more useful in learning isolated information, such as words in the foreign language or concepts in a particular order. We found the strongest correlation between the two organizational strategies (basic and complex) and the test score. Accordingly, the organizing strategies were the most useful for students learning about colour perception. When combined with the elaboration strategies, they were likely used to reorganize and reshape the information into a new, subjectively adapted knowledge structure that better matched their individual understanding (e.g., explaining the process of colour perception, explaining why we don't perceive colours in the dark).

Research has shown that girls are on average more academically successful than boys (Hočevar, 2014) and boys are more positive about learning in the digital environment (Liu & Huaung, 2007), so our aim was also to investigate the differences in the effectiveness of learning with digital text between boys and girls. We found a significant relationship between gender and notetaking; girls were more likely to take notes than boys. This finding is congruent with several studies that found that girls are more likely to use learning strategies (Ghiasvand, 2010; Pečjak & Košir, 2003) and are more aware of their importance (Tomec et al., 2006). This metacognitive awareness of the importance of strategy use is likely to be the key component in their decision to use them and thus achieve higher achievement. Since girls' anxiety levels in the digital environment are higher than boys' (Cooper, 2006) and they feel less competent in this regard (Hargittai & Shafer, 2006; Tsai & Tsai, 2010), using learning strategies may also help them overcome their insecurities and lower their anxiety levels. Boys, on the other hand, because they are more confident and positive about digital sources, may find notetaking redundant.

Conclusions

We found an important relationship between the use of learning strategies and learning success in the e-environment, with this relationship being slightly stronger for deep strategies (elaboration and organization). We also found gender differences in learning with digital text, similar to those we find in the traditional environment. Thus, in the digital environment, it is important to help students, especially boys, recognize the usefulness of strategy use and help them learn how to use them, especially the deep learning strategies.

The advantage of our study is that it includes both a qualitative and a quantitative analysis of the relationship between learning strategies and learning achievement in learning with digital text. However, one of the main limitations is the lack of control for individual differences (e.g., motivation, anxiety level, time spent in learning, etc.) that could influence the learning process and the use of learning strategies. Furthermore, the use of additional online measures to observe cognitive self-regulatory processes (e.g., eye movements, etc.) and the think-aloud method would provide additional insights into the use of cognitive as well as metacognitive learning strategies.

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