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Original Article

Effects of the Know-Want-Learn Strategy on Primary School Students' Metacognition and Physics Achievement

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Abstract

This study is aimed at examining the effects of the Know-Want-Learn (KWL) strategy on primary school students' metacognition and physics achievement. A pre-test – post-test control group design was used, where the treatment was the implementation of the KWL strategy. A physics knowledge test and a questionnaire about metacognition were administered to sixth-grade primary school students of both genders. The results obtained were treated statistically, using descriptive statistics and a paired-samples t-test, as well as an independent samples t-test. The analysis of the results obtained showed that for both variables (physics achievement and metacognition): (1) there was no significant difference between the pre-test and post-test scores for the group of students who had been taught traditionally, (2) there was a significant difference between the pre-test and post-test scores for the group of students who had been taught by the use of KWL strategy and (3) there was a significant difference in the post-test scores between the group of students who had been taught traditionally and the group of students who had been taught by the use of the KWL strategy. Important insights about the effects of the KWL strategy in learning physics have been generated.

Keywords: *learning strategy, metacognitive strategy, students' performance*

Introduction

According to Taslidere and Eryilmaz (2012), in recent decades researchers have studied the problem of students' inadequate reading and study habits (Hartlep & Forsyth, 2000), their unwillingness to study physics and their difficulties in understanding it (Hewitt, 1990). Students are used to relying upon teachers for constant support, instead of being independent learners, aware of their own learning. Those problems are reflected in students' physics achievements. The above mentioned problems are also related to students' metacognition.

Metacognition

Metacognition is important for learning physics (Akyüz, 2004; Bogdanović et al., 2015). According to Flavell (1976), who originally came up with the term metacognition, the term refers to "one's knowledge concerning one's own cognitive processes and products" (p. 232). Various researchers indicate that the concept of metacognition does not have a clear extent, but that it refers to one's thinking process, monitoring and control of thinking (Hacker, 1998; Posner, 1989; Weinert & Kluwe, 1987). According to one definition, metacognition is the knowledge and control one has over their own thinking and learning activities (Cross and Paris, 1988). Kuhn and Dean (2004) stated that metacognition was the awareness and management of one's own thoughts. Martinez (2006) defined metacognition as the monitoring and control of thought, and according to Ormrod (2004), it is what one knows about his own cognitive processes and about using these processes for learning. Generally, metacognition is defined as the activity of monitoring and controlling one's cognition (Weinert & Kluwe, 1987), or in simpler terms- as "cognition about cognition", i.e. "thinking about thinking" and "knowledge about knowledge".

According to the first framework given by Flavell (1979), metacognition can be categorized into: metacognitive knowledge, metacognitive regulation and metacognitive experiences. Metacognitive knowledge includes: declarative knowledge, procedural knowledge and conditional (strategic) knowledge (Schraw & Moshman, 1995). Declarative knowledge refers to how to do something. Procedural knowledge covers the skills, strategies and resources required to perform the task (knowledge of how to perform something). Conditional knowledge is knowledge of when to apply a certain strategy. Metacognitive regulation refers to the awareness of the need to use certain strategies, such as planning, information management, monitoring, evaluation and debugging in the process of thinking and learning (Schraw & Dennison, 1994). Metacognitive experiences represent the feelings, estimates or judgments related to the features of the learning task, the cognitive processing as it takes place, or of its outcome. For example, the tip of the tongue phenomenon is very common. According to Efklides (2009), the critical feature of metacognitive experiences is their affective character.

Metacognition is an important aspect of students' learning; it helps students learn the material more efficiently, retain knowledge longer and generalize skills (Ahmadi et al.,

2013). Metacognition enables students to solve new problems by retrieving the strategy that they have successfully used in a similar context (Kuhn & Dean, 2004). Students with highly developed metacognition are convinced that they can learn, they take some time to reflect on their learning and they are accurate when evaluating their success in learning. They think about the errors that have occurred while they were performing tasks, and they are successful in connecting and adjusting learning strategies to the tasks at hand (Rahman et al., 2010).

Although it is known that metacognitive strategies help improve students' metacognition, they are not included in today's school practice due to inadequate resources and a lack of opportunity for professional development.

Know-Want-Learn Strategy

The Know-Want-Learn (KWL) strategy is an instructional learning strategy, first suggested by Ogle (1986) as a reading strategy. It is an active learning strategy (Bryan, 1998; Jared & Jared, 1997; Ogle, 2009) which supports student-centred learning (Draper, 2002). The KWL is a simple and effective reading strategy that is applicable in different school subjects (Brozo & Simpson, 1991, Foote et al., 2001).

The KWL strategy consists of three basic stages: (1) accessing previous knowledge, (2) determining what one wants to know and (3) recalling what is learned (Blachowicz & Ogle, 2008). This strategy is designed in a form of the KWL chart as an organizing instrument that can be successfully used in order to inspire students' inquiry (Camp, 2000; Ogle, 2009). It helps students to adopt given concepts and also to activate prior knowledge and assess what they have learned (Camp, 2000; Martorella et al., 2005). The KWL chart consists of three columns: What I Know (K), What I Want to know (W) and

What I Learned? (L) (Figure 1). The KWL strategy is devised in such a way so as to be suitable to be used by a teacher working together with all students in the classroom; it can also be easily transformed into a method for students' independent study (Ogle, 2005; Tok, 2013). KWL charts can be applied in schools through the following steps:

- Students brainstorm about what they already know about a topic and write their responses in the first column of the chart;
- Students brainstorm about what they would like to know about the topic and write their responses in the second column of the chart;
- Learning activities and reading;
- Students return to the chart and fill in what they have learned in the third column of the chart, paying special attention to the information that is related to what they wanted to know;

Topic: ______ Before you begin learning, list details in the first two columns; after completing that, fill in the last column.		
*What I **K**now*	*What I **W**ant to know*	*What I **L**earned*

Figure 1. The KWL chart.

Also, there are modified KWL strategies where charts are adjusted for different students' activities, for example, the KWLH chart, where additional H stands for How can I learn more. In this case, students are encouraged to think about the possible ways of expanding their knowledge, i.e. H encourages future learning (Weaver, 1994).

By applying the KWL strategy, students are encouraged to be mentally active during the learning process, they practice developing suitable questions for the given topic and they develop skills in organizing their prior knowledge about the topic and in evaluating their success in learning (Taslidere & Eryilmaz, 2012). The KWL strategy directs students towards perceiving learning as a metacognitive process (Ogle, 2005); it can, therefore, be considered as a metacognitive strategy. Various research results indicate that the KWL strategy increases students' metacognition (Mclain, 1993; as cited in Tok, 2013). The KWL strategy develops students' metacognition by increasing their awareness (Mok et al., 2006) and helps students to establish a purpose for reading and to monitor their comprehension (Szabo, 2006). The use of the KWL strategy makes learning and remembering easier (Gammill, 2006) and encourages complete understanding of a topic, since students study a specific question that they are interested in (Jared & Jared, 1997). Accordingly, it can be a good learning strategy for acquiring physics contents.

Methods

Aim of Research and Research Hypotheses

The research was conducted with the aim to examine the effects of the KWL strategy on primary school students' physics achievement and metacognition. In accordance with the given theoretical framework, the following research hypotheses were formulated:

1. There is no significant difference between the pre-test score in the physics knowledge test (PKTi score) and the post-test score in the physics knowledge test (PKTf score) for the group of students who were taught traditionally (group C).
2. There is no significant difference between the pre-test score in the questionnaire about metacognition (QMi score) and the post-test score in the questionnaire about metacognition (QMf score) for the students in group C.
3. There is a significant difference between the PKTi score and the PKTf score for the group of students who were taught by using KWL strategy (group E).
4. There is a significant difference between the QMi score and the QMf score for the students in group E.
5. There is a significant difference in the PKTf scores between the students in groups E and C in favour of group E.
6. There is a significant difference in the QMf scores between the students in groups E and C in favour of group E.

Research Sample

A sample of 101 sixth grade students (aged 11–12 years) of both genders (47 males and 54 females) was used for the purpose of this research. These students were enrolled in four different classes of a state primary school in Subotica, and it was the first time that physics was introduced as a separate school subject for them (in their sixth grade).

Design and Procedure

A pre-test – post-test control group design was used. Since the groups were pre-constituted (in the form of school classes) the participants could not be randomly assigned to the groups. This is often the case in educational research and researchers have to choose a control group that is as similar to the experimental group as possible (Muijs, 2004; as cited in Tok, 2013). Both groups were pre-tested in order to determine whether they were matching. An independent samples t-test showed that there was no significant difference in the PKTi scores of the students in group E ($M=9.78$, $SD=4.26$) and group C ($M=10.38$, $SD=4.28$); $t(99)=-0.70$, $p=0.485$. Also, there was no significant difference in the QMi scores of the students in groups E ($M=70.65$, $SD=8.33$) and C ($M=71.22$, $SD=7.65$); $t(99)=-0.36$, $p=0.720$. The KWL strategy was applied to (experimental) group E and the traditional teaching method was applied to (control) group C. After group E had been administered the treatment, both groups were post-tested. Both groups were taught by the same physics teacher.

Treatment

The treatment was administered to group E during the realization of the unit Mass and Density within 15 school hours. The topic Mass and Density was covered as a part of the regular physics classroom curriculum. Students in both groups (E and C) were exposed to the same content for the same period of time.

The KWL strategy was first implemented during one school hour in such a way that the teacher and all the students in the class were working together. The teacher was drawing the KWL chart on the board and the students were writing in their notebooks. During the next physics class, the teacher was first having a discussion with the students about each of the KWL strategy components and then, assisted by the teacher, the students filled in the KWL charts while working in groups. Afterwards, the students individually started to write their own KWL charts, following the given instructions as how to do it, so that later they were able to do their homework by themselves, by filling each column of the KWL chart in their physics notebooks.

Research Instruments

Physics Knowledge Test

A physics knowledge test covering the unit Mass and Density was administrated for post-testing. The test consists of 12 multiple-choice tasks on the basis of which students'achievement in physics is assessed (tasks were on all levels of knowledge). The quality of the test was examined by estimating test validity and reliability. The validity of the test was estimated in accordance with Segedinac et al. (2011; as cited in Hrin et al., 2015), based on the evaluation of an expert team. Two primary school physics teachers, a school pedagogue and a university instructor analyzed the test items to determine whether they are readable, understandable and suitable. The expert team concluded that the test was valid. Task requirements were meaningful, the applied terminology and the length of sentences were appropriate for sixth-grade students. The test was constructed in accordance with the curriculum regulations, as well as with the recommended textbook. The obtained Cronbach's alpha coefficient of 0.66 indicated that the test satisfied the requirement for reliability. The time assigned for the test was 45 minutes.

The following are examples of the test questions in terms of knowledge, comprehension and application:

1. The kilogram is the base unit of measurement:
   a) weight
   b) density
   (c) mass
2. If two bodies have equal masses, and the volume of the first body is greater than the volume of the second:
   a) The first body is denser than the second body
   (b) The first body is less dense than the second body
   c) We cannot know how to relate the density of the first and the second body
3. The metal object is made of equal masses of the following two materials: bronze and silver. The volume of the object is 4.18 cm3 and its mass is 40 g. The density of bronze is 8800 kg/m^3. What is the density of silver?
   a) 10500 g/cm^3
   (b) 10500 kg/m^3
   c) 9.5 mg/m^3

A Questionnaire about Metacognition

A questionnaire about metacognition was constructed for this research. The Junior Metacognitive Awareness Inventory (Jr. MAI), developed for children under the age of 14 by Sperling et al. (2002), was adapted. The Metacognitive Awareness Inventory (MAI) was first proposed in the early nineties by Schraw and Dennison (1994). MAI questionnaire is intended to assess metacognitive skills of adolescents and adults and contains items that examine each of the eight components: knowledge of cognitive processes (declarative, procedural and conditional) and regulation of cognitive processes (planning, information management, monitoring, evaluation and debugging in thinking process). The questionnaire about metacognition used in this research consisted of 18 items with a five-point response The Likert Scale, appropriate for the selected sample (the choice of items was made based on the capability of students to understand the items that constitute the scale, which was tested by a pilot survey on a similar research sample). Students were asked to respond to the statement using a five-point Likert Scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The Cronbach‘s alpha coefficient for internal consistency reliability test was used. The obtained Cronbach’s alpha coefficient was 0.70 which, according to George and Mallery (2003), indicated that the scale of the instrument satisfied the requirement for reliability. The time assigned for the questionnaire was approximately 15 minutes.

Examples of items in MAI:

I know when I understand something.

I try to use the ways of studying that have worked for me before.

I learn best when I already know something about the topic.

I learn more when I am interested in the topic.

I think of several ways to solve a problem and then choose the best one.

I draw pictures or diagrams to help me understand while learning.

Statistical Analysis of Data

After the logic check and coding of the collected data, a statistical analysis of the results was performed. Variables were described by the means of statistical measures (average measures, measures of variability and measures of distribution shape). Since all the scores, PKTi, PKTf, QMi and QMf, satisfied the requirements of normal distribution, a paired samples t-test was used in order to compare the pre-test and post-test scores. Furthermore, to determine differences between the students in Groups E and C, an independent samples t-test was conducted. A statistical analysis of data was performed using the software package IBM SPSS 20.

Results

Students’ Physics Achievement

Students’ test scores, both PKTi and PKTf, could range from 0 to 20 points. A higher score in the test denotes greater physics achievement. Table 1 indicates that Group E students increased their test scores (from the PKTi to the PKTf) by 4.32 points. A paired samples t-test was conducted to compare the PKTf and PKTi scores. There was a significant difference in the PKTf ($M=14.10$, $SD=4.39$) and the PKTi ($M=9.78$, $SD=4.26$) scores for the students in Group E; $t(50)=-5.16$, $p=0.000$.

However, there was no significant difference between the PKTi ($M=10.38$, $SD=4.28$) and PKTf ($M=11.04$, $SD=4.38$) scores for the students in Group C; $t(49)=-1.58$, $p=0.120$.

An independent samples t-test was conducted to compare PKTf scores between the students in Groups E and C. There was a significant difference in the PKTf scores of the students in Group E (M=14.10, SD=4.39) and Group C (M=11.04, SD=4.38), in favour of the students in Group E; t (99) =3.50, p=0.001.

Table 1. Basic descriptive statistics related to physics knowledge test scores.

	C group		E group	
	PKTi	PKTf	PKTi	PKTf
N	50	50	51	51
Mean	10.38	11.04	9.78	14.10
Standard deviation	4.28	4.38	4.26	4.39
Minimum	3.0	3.0	3.0	5.0
Maximum	20.0	20.0	19.0	20.0
Stnd. skewness	0.23	-0.56	0.76	-1.36
Stnd. kurtosis	-1.10	-1.12	-1.27	-1.09

According to these results, it can be suggested that the use of the KWL strategy really increases students' physics achievement.

Students' Metacognition

Students' scores in the questionnaire, both QMi and QMf, could range from 18 to 90 points. A higher score in the questionnaire indicated a higher level of development of metacognition. Table 2 indicates that Group E students increased their scores in the questionnaire (from the QMi to the QMf) by 4.25 points. A paired samples t-test was conducted

Table 2. Basic descriptive statistics related to scores in the questionnaire about metacognition.

	C group		E group	
	QMi	QMf	QMi	QMf
N	50	50	51	51
Mean	71.22	70.10	70.65	74.90
Standard deviation	7.65	8.01	8.33	7.15
Minimum	57.0	54.0	54.0	56.0
Maximum	87.0	86.0	87.0	88.0
Stnd. skewness	-0.41	-0.69	-0.76	-1.31
Stnd. kurtosis	-0.85	-0.76	-0.93	0.87

to compare the QMf and QMi scores. There was a significant difference in the QMf (M=74.90, SD=7.15) and QMi (M=70.65, SD=8.33) scores for the students in Group E; t (50) =-3.78, p = 0.000.

On the other hand, for the students in Group C scores did not statistically differ from the QMi (M=71.22, SD=7.65) to the QMf (M=70.10, SD=8.01); t (49) =-0.914, p=0.365.

An independent samples t-test was conducted to compare QMf scores between the students in Groups E and C. A significant difference was found in the QMf scores between the students in Group E (M=74.90, SD=7.15) and Group C (M=70.10, SD=8.01), in favour of the students in Group E; t (99) = 3.18, p=0.002.

These results imply that the use of the KWL strategy increases students' metacognition.

Discussion

Based on the results of this research, all the proposed research hypotheses are accepted. Hence, it can be stated that the application of the KWL strategy in the sixth-grade physics class is effective in increasing students' physics achievement and metacognition. It encourages students' metacognition and helps them to be successful in learning physics contents. These findings are consistent with the findings of other researchers that have examined the efficiency of the KWL strategy.

The findings of this research are in parallel with the findings of Tok (2013), who conducted research in order to examine the effects of the KWL strategy on sixth graders' mathematics achievement, metacognitive skills and mathematics anxiety. Al-Khateeb and Idrees (2010) examined the impact of using the KWL strategy on tenth-grade female students' reading comprehension, and based on the results they suggested that the KWL strategy increased students' achievement. Various researchers showed that the use of the KWL strategy increased students' achievement in science classes (Akyüz 2004; Taslidere & Eryilmaz, 2012; Reichel, 1994; as cited in Tok, 2013). Akyüz (2004) examined ninth grade students' achievement regarding the topic Heat and Temperature when the KWL strategy was used, and suggested that the use of this strategy increased students' achievement. Taslidere and Eryilmaz (2012) conducted research to examine the relative effectiveness of the integrated reading strategy and the conceptual physics approach on ninth grade private high school students' achievement in Optics. Their results showed that the reading strategy and the conceptual physics approach combined, improved students' achievement significantly, and they used the KWL strategy as the reading strategy. Reichel (1994; as cited in Tok, 2013) suggested that the use of the KWL strategy had a positive effect on student performance in the science classroom. Writing in the What I Know column activates students' previous knowledge and writing in the What I Want to Know column helps students to recognize the purpose of learning (Cantrell et al., 2000). Those activities contribute to the efficiency of the KWL strategy. Proposing questions and giving answers promote content comprehension (Davis, 1993), which largely reflects on physics achievement. The findings of this research are also in parallel with findings of other researchers about the effects of metacognitive strategies, including the KWL strategy, on students' metacognition (Mok et al., 2006; Ngozi, 2009; Ozsoy & Ataman, 2009; Tok, 2013). Mok et al. (2006) showed that the KWL strategy also had a positive effect as a tool for self-assessment and that it was efficient for promoting metacognition. Ngozi (2009) showed that students in the higher grades of secondary school who had practiced metacognitive strategies achieved better results within the sciences. Also, it was shown that the fifth-grade students in the group where a strategy for fostering metacognitive abilities had been applied significantly improved their metacognitive abilities and the skills of solving mathematical problems (Ozsoy & Ataman, 2009). The KWL strategy makes students be more engaged in the text and practice metacognition while reading. While writing the KWL chart, students must use metacognitive regulation, i.e. planning, information management, monitoring and evaluating. In that way, students' metacognition is promoted throughout the learning process (Mok et al. 2006).

Conclusions

It can be very useful to implement the KWL strategy in school practice since it is both a metacognitive strategy and a good learning strategy. In order to successfully implement the described strategy, it is necessary to provide adequate resources and professional development for teachers.

The main problem of this research is the fact that the groups were not completely isolated. This is the common problem of the pre-test – post-test designs in educational research, since children attending the same school socialize outside the school and share ideas. It should be noted that the research was limited to a sample consisted of sixth-grade students and that only one topic from the physics curriculum was treated.

Based on the research results, there are implications that further research is necessary. In order to obtain new results and, therefore, confirm the results of this research, similar research that includes more extensive teaching and learning material is needed, as well as research with a sample that includes students of the seventh and eighth grades, especially because in that age group metacognitive skills are developed rapidly.

The KWL strategy has not been sufficiently studied, which leads to the conclusion that many results concerning its implementation are yet to be obtained within future research. Research that includes the implementation of modified KWL strategies in physics teaching and learning can be very interesting.

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