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The impact of using the modified Know-Want-Learn strategy in physics teaching on students' metacognition

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To make it easier for students to learn the contents of physics and increase their motivation to learn, physics teachers need to apply different teaching strategies. With this study we aimed to examine the impact of the modified Know-Want-Learn (mKWL) strategy in physics teaching on elementary school students' metacognition. The pedagogical experiment with parallel groups was applied to determine whether the mKWL strategy affected students' metacognition. The students in the experimental group were taught by applying the mKWL strategy with a specific chart. The chart consisted of columns: T – What I think and what I know, Q – What questions I have, H – How can I find out, L – What I Learned (TQHL chart). The students in the control group were taught (the same physics curriculum) by using the traditional teaching model, without this TQHL chart. A questionnaire on metacognition was used for the evaluation of sixth-grade students' metacognition. The statistical analysis of data included descriptive statistics, as well as paired sample *t*-tests and independent sample *t*-tests. Research results, based on the scores obtained using the questionnaire on metacognition, imply that the use of the proposed mKWL strategy increases students' metacognition. Considering the positive effect of this teaching strategy on students' metacognition, its further application in other teaching subjects is planned as well as the training of a large number of elementary school teachers for its application.

Keywords: elementary school; modified KWL strategy; students' metacognition; teaching physics

Introduction

Students' learning is affected by a general problem. Students are unaware of their activities while learning, and consequently, they are not successful in independent learning but need ongoing support from teachers. Field, Duffy and Huggins (2015) indicate that university students are unprepared for independent learning and that deliberate instruction in the development of independent learning skills is needed in the first-year curriculum. The situation in schools is not encouraging, for instance, it is estimated that up to 75% of learners in South Africa (learners in low-quintile South African schools) show low science and mathematics performance (Spaull & Kotze, 2015, cited in Stott, 2018) and show low levels of general skills, such as reading comprehension (Pretorius & Spaull, 2016). This is partly due to poor language used in learning and teaching (Pretorius, 2015). Furthermore, students often have poor prior knowledge; both learners and teachers have poor skills needed in the teaching and learning process, and time is used ineffectively due to a lack of teaching activities (Van der Berg, Spaull, Wills, Gustafsson & Kotzé, 2016, cited in Stott, 2018). The problems stated above have a negative impact on students' performance and are related to students' metacognition (Pintrich, Wolters & Baxter, 2000; Wenglinsky, 2001).

Learning problems are most pronounced in complex school subjects. For instance, the results of the Program for International Student Assessment (PISA) tests (Organisation for Economic Co-operation and Development [OECD], 2019) indicate that students finishing elementary school in the Republic of Serbia do not have satisfying functional physics knowledge. When it comes to learning physics, a similar problem exists in most countries.

Considering that physics is often characterised as a difficult, abstract and uninteresting school subject (Ancell, Guttersrud, Henriksen & Isnes, 2004; Checkley, 2010), physics teachers should use different teaching strategies such as clicker questions, peer discussions, quizzes, group quizzes, and others like graphic organisers that promote active learning and collaboration (De Grandi, Mochrie & Ramos, 2019; Tandog & Bucayong, 2019). Teachers should use strategies that foster students' knowledge and learning processes in general (Cromley, 2000). Both nationally and internationally, the need for improving science and technology education arises since these disciplines are considered important for developing effective citizens in modern societies (Butterfield, 2012; Yore & Treagust, 2006). Improving science education should refer to helping students to acquire knowledge better and also to develop skills to think and learn on their own (metacognition).

Literature Review

Concept of metacognition

Unlike cognition, which implies the ability to process information (acquiring knowledge, understanding through thought, experience, and the senses), metacognition can be defined as the knowledge of one's own cognitive processes (Flavell, 1979). It is the ability to control own thinking processes through various learning strategies, such as organising, monitoring, and adapting (Hacker, 1998; Posner, 1989). Metacognition, which has three large components, namely, metacognitive experience, metacognitive knowledge, and metacognitive strategies (Schmitz, 2012) can be considered as very important in successful learning.

Metacognitive knowledge includes many different elements such as learning processes, beliefs about learning, the tasks of learning and the learning strategies, which are developing during the learning process. This knowledge can be declarative (the *what*), procedural (the *how*) and conditional (strategic) (the *when* and *why*) (Schraw & Dennison, 1994; Schraw & Moshman, 1995). Schraw, Crippen and Hartley (2006) define declarative knowledge as knowledge about factors that influence one's performances (i.e. knowledge about one's skills, intellectual resources). Many authors have presented the definition of declarative knowledge as knowledge about one's ability as a learner (e.g. Mevarech & Fridkin, 2006; Schraw & Dennison, 1994). Procedural knowledge has been observed as knowledge about how to use learning procedures and strategies (Schraw & Dennison, 1994). Finally, conditional knowledge refers to the timing of the application of a particular learning strategy or knowledge of when and why to apply a particular learning strategy (Schraw et al., 2006; Schraw & Dennison, 1994).

The importance and development of metacognition

Knowledge of concepts and facts, and fundamental skills provide a basis for developing metacognition. It is a very important factor for the learning process because it enables students to master a large amount of information. Thus, they can solve new problems, learn the content easily and efficiently retain knowledge (Kuhn & Dean, 2004). Students who have more developed metacognition are very successful in adapting and correlating different learning strategies (Rahman, Jumani, Chaudry, Chisti & Abbasi, 2010).

Malcolm and Alant (2004) imply that the research on science learning with a focus on the learning process could be useful. In various studies the researchers showed that students' metacognition can be improved by using metacognitive strategies and that highly developed metacognition can further improve learning in various disciplines, including science (Bogdanović, Obadović, Cvjetićanin, Segedinac & Budić, 2015; Desoete, 2007; Joseph, 2009; Yore & Treagust, 2006). However, metacognition is often neglected in the teaching process. For instance, Van der Walt and Maree (2007) suggest that mathematics educators in South Africa do not implement metacognitive skills to a sufficient extent. The existing problem can be partially overcome by including appropriate strategies in the teaching process (Ellis, Denton & Bond, 2014).

Many metacognitive strategies for classroom instruction were presented by various authors (Dike, Mumuni & Chinda, 2017; Medina-Martínez & Pagán-Maldonado, 2016; Ricky & Stacy, 2000). Researchers from this field were looking for effective classroom instructions that increase not only students' learning performances (knowledge test achievements), but also metacognitive learning skills. For instance, Assan (2019) indicates that teachers should become more resourceful in terms of their learning and teaching strategies so they can facilitate effective learning. Van Aswegen, Swart and Oswald (2019) show that using stories in work with young students (age 9 to 10) can be an effective learning tool for developing metacognition. Tachie (2020) shows that teachers consider lesson study as an appropriate strategy for improving both teaching and learning mathematics. Akuma and Callaghan (2019) examined the implementation of inquiry-based practical work and indicated related challenges.

The Know-Want-Learn strategy and its modifications

The Know-Want-Learn (KWL) strategy can be considered as a metacognitive strategy. It is learning instruction which originally emerged as a reading strategy (Ogle, 1986). The KWL strategy supports student-centred active learning (Bryan, 1998; Draper, 2002; Ogle, 2009). In this way, with increasing students' awareness, their metacognition is developed (Mclain, 1993; Mok, Lung, Cheng, Cheung & Ng, 2006; Tok, 2013).

The KWL strategy has three steps. The first step is the activation of students' prior knowledge and their assessment of what they have already learned about the topic. In the second step, they determine what they want to know and in the third step (after instruction), they recall what was learned (Blachowicz & Ogle, 2008). This information is labelled in a special graphic organiser called a KWL chart (Camp, 2000). This chart has three columns: What I know (K), What I Want to know (W) and What I learned (L)?

The KWL strategy can be modified very simply if an additional fourth column, How can I learn more (H), is added to create the KWLH chart. This additional column gives students the opportunity to think of possible ways of expanding their knowledge. Henceforth, future learning is supported (Weaver, 1994).

Another modification of the KWL strategy uses the TQHL chart (cf. Table 1). This chart was constructed and first reported by Zouhor, Bogdanović, Skuban and Pavkov-Hrvojević (2017). The authors believed that it was convenient to make another adjustment to the original KWL chart in order to activate students' previously generated knowledge in the domain of physics, and to encourage them to present their own thoughts.

Table 1 The TQHL chart

What I think and what I know (T)	What questions I have (Q)	How can I find out (H)	What I learned (L)

This modification adds the concept of thinking to the first column. This was previously done in Crowther and Cannon's (2004) modification, who proposed the THC (What do you **T**hink? – **H**ow can we find out? – What do we **C**onclude?) strategy. Crowther and Cannon (2004) observed the need that KWL, originally a reading strategy, should evolve as a strategy applicable in the science classroom, with the aim to train students to think like scientists. Additionally, in the second column of the TQHL chart, the questions about the topic are defined. Of particular importance is the third column, which lists the ways to find out about the topic (lesson). Similarly, Crowther and Cannon (2004) added column H (How can we find out) in order to encourage students to propose the ideas that could lead to different ways of inquiry. In the fourth column, as in the original version and previous modifications (KWL and KWLH), it is stated and considered what was learned after the realisation of teaching this topic. Considering this modification, it can be concluded that it introduces concepts of thinking and definition of issues (questions) related to the topic.

Although KWL was first used as a reading strategy, it started being widely used in various teaching subjects as learning instruction (Foote, Vermette & Battaglia, 2001). The application of this strategy supports the processes of learning (Gammill, 2006) and encourages students' understanding. It should be highlighted that a modified KWL strategy can be used in teaching with all students or in an individual approach, whereby each student can access his own individual study (Tok, 2013).

The use of the KWL and mKWL strategies successfully inspires student inquiry (Ogle, 2009). The use of the KWL charts leads students to think about their prior knowledge, about what they want to find out (making them wish to inquire) and in some chart modifications students are explicitly asked to think of an appropriate inquiry strategy. Thus, KWL charts turn the teachers and students toward a more inquiry-based approach and facilitate a more student-centred and collaborative learning environment. During teacher training for the application of these strategies, teachers gain the confidence to apply inquiry-based elementary science. They recognized inquiry-based science as an effective factor for engaging students' learning (Lewis, Dema & Harshbarger, 2014). It raises the level of interest and the amount of personal input given by the students (Alshatti, Watters & Kidman, 2012). Those charts helped students to adopt given concepts and activate their prior knowledge (Martorella, Beal & Bolick, 2005; Mesa, Pringle & King, 2014) and were helpful in reading comprehension (Rosari & Mujiyanto, 2016).

In various studies, researchers examined the implementation of the KWL strategy and its modifications. For instance, Greenwood (2019) informs that the opinions of teachers and pupils about how the KWL strategy can involve pupils in planning class topics are generally positive with few concerns about difficulties for the implementation of the strategy. Baird and Coy (2020) describe the implementation of an expanded Observe-Wonder-Learn chart as a tool for assessing students' prior knowledge and a unit-planning tool. Delisio, Bukaty and Taylor (2018) carried out research in order to examine the effects of the modified KWL strategy proposed by Barton and Heidema (2000) on the solving of mathematical word problems by students with autism spectrum disorders. Although the positive effect of the implementation of the strategy is not shown in their research and due to research limitations the definite conclusions could not be drawn, the insights given by the researchers indicate the direction for future studies. Usta and Yılmaz (2020) suggest that the implementation of the KWL strategy in teaching fourth graders mathematics fostered the students' problem-solving achievement and Johan, Suyitno, Mashuri and Sayekti (2020) suggest that the implementation of the KWL strategy had a positive impact on the reasoning skills of seventh-grade students. Similarly, Alsalhi (2020) showed that the implementation of the KWL strategy in teaching fourth-grade science topics positively impacted both students' achievement in science and their attitudes.

The application of the KWL strategy is useful for formation and consideration of different physics concepts and the realisation of school practice (Mihardi, Harahap & Sani, 2013; Taslidere & Eryilmaz, 2012; Zouhor, Jaškov & Bogdanović, 2016). In their study, Zouhor, Bogdanović and Segedinac (2016) highlighted the positive effect of the KWL strategy on primary school students' performances on a physics knowledge test and metacognition. The mKWL strategy, with the application of the TQHL chart, was previously examined in the study by Zouhor et al. (2017), observing primary school level physics content, where it was found that the applied mKWL strategy had a positive effect on students' test performances. It should be highlighted that this study is the second part of the previously described research.

Methodology

The Aim of Research, Research Question and Research Hypotheses

After looking into relevant literature about the topic, one can easily conclude that the implementation of the KWL strategy and its modifications in physics teaching should receive more attention. In particular, examining the impact that the mKWL strategy could have on students' metacognition deserves special attention.

Since it is shown that the mKWL strategy implemented in physics teaching increases students' physics performance (Zouhor et al., 2017), it can be useful to examine if the same strategy also impacts students' metacognition. If it is shown that one strategy has a positive impact on both students' performance and metacognition (and/or other variables such as students' motivation for learning), that strategy can be considered as more appropriate than the strategy positively impacting only students' performance (that is content knowledge acquiring). Moreover, since metacognition is very important for successful learning, it is important to identify metacognitive strategies that enable content knowledge acquiring and accordingly can be easily implemented in school practice.

The aim of this research was to analyse the effect of the mKWL strategy with the TQHL chart in teaching physics on elementary school students' metacognition. The research direction was a consequence of the previous research (Zouhor et al., 2017) in which the effect of the same strategy on students' performances on the physics knowledge test was examined.

From the stated aim of the research, the following research question emerged: Does the mKWL strategy affect sixth-grade students' metacognition?

Taking into account the given theoretical framework and research question, the research hypotheses were defined as follows:

1) There is a significant difference in the results of the questionnaire on metacognition for the experimental group students before (QMi – questionnaire on metacognition pre-test score) and after the experiment (QMf – questionnaire on metacognition post-test score);
2) There is no significant difference in the results of the questionnaire on metacognition for the control group students before (QMi score) and after the experiment (QMf score);
3) Before the experiment, there is no statistically significant difference between experimental and control groups in the results of the questionnaire on metacognition (QMi score);
4) There is a significant difference in the QMf scores between the experimental and control groups students, in favour of the experimental group.

Research Methods

The following methods were applied in the research: (1) analytical method, primarily in the analysis of the available proposals and recommendations of implementation of the mKWL strategies; (2) pedagogical experiment with parallel groups – experimental (E) and control (C); (3) statistical method in the processing of the obtained data.

Research Sample

Elementary education, as a compulsory part of the education system in the Republic of Serbia, last 8 years. Physics, as a stand-alone subject, is first introduced in the sixth grade of elementary school (students aged 12 years) with two classes per week (following the school curriculum determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia). The research included a sample of 110 sixth-grade students (51 boys, 46.36%, and 59 girls, 53.64%) from an elementary school in Subotica, Republic of Serbia. The selected elementary school was suitable because the physics teacher employed there was trained for implementing the TQHL charts in physics classes. He was included in the pilot study (Zouhor, Bogdanović, et al., 2016) when he was trained for implementing the KWL strategy in physics classes. Before the current study, he had completed all necessary preparation.

The students were grouped into Group E (N = 58) and Group C (N = 56). Before the introduction of the experimental factor (the mKWL strategy with the TQHL chart) in Group E, the groups were made uniform concerning the number of students, gender and general knowledge of physics, as determined by the results of a pre-test of knowledge. Firstly, students from the five classes were subjected to the physics pre-test. In order to examine whether the obtained data satisfied the requirements of normal distribution, a Shapiro-Wilk test was performed and the test statistic (labelled W) is reported together with its significance level (labelled p). It is shown that the data satisfied the requirements of normal distribution. For the students in Group C, the PKTi (physics knowledge pre-test) score probability of the observed value, W = .968, was: p = .157; and for the PKTi score of the students in Group E:

W = .96, p = .059), and henceforth, an independent sample t-test was applied. The t-test statistic (labelled t) is reported together with its significance level (labelled p) and also the mean (M) and standard deviation (SD) are given for each group. Following the results of the t-test (t = - 0.83, p = .41), two classes were selected as Group E (M = 9.95, SD = 4.52), and two other classes as Group C (M = 10.7, SD = 4.57).

Before the research was performed, the necessary consent was obtained from parents, teachers, and the school administration. Students who participated in the research were voluntarily included, and their privacy was fully respected.

Research Instrument and Procedure

Evaluation of students' metacognition before and after implementation of the mKWL strategy was carried out by using a questionnaire on metacognition. The adapted Junior Metacognitive Awareness Inventory (JrMAI), developed for children under the age of 14 by Sperling, Howard, Miller and Murphy (2002), was employed. JrMAI evaluates all the following metacognitive components: declarative, procedural and conditional knowledge, planning, information management, monitoring and evaluation. It consists of 18 items with a 5-point Likert scale, convenient for the selected sample. Students were required to reflect on statements ranging from "Strongly disagree" (1) to "Strongly agree" (5). Examples of items: "I am a good judge of how well I understand something; I try to use strategies that have worked in the past; I know what the teacher expects me to learn; I ask myself questions about how well I am learning while I am learning something new; I ask myself if there was an easier way to do things after I finish a task." The data obtained using JrMAI were tested for internal consistency, calculating the Cronbach's alpha coefficient. The obtained value of .70 indicated satisfactory inter-item correlations (George & Mallery, 2003). In the first physics class of the pedagogical experiment, the teacher notified students about the research and supplied each student with a questionnaire (QMi). The students completed the questionnaire in the 15 minutes allocated. Afterwards, students returned the completed questionnaires to the teacher and the class continued.

The research was carried out during 14 school weeks (28 school hours) in total. The research started in March of the 2015–2016 school year (cf. Figure 1 – research design).

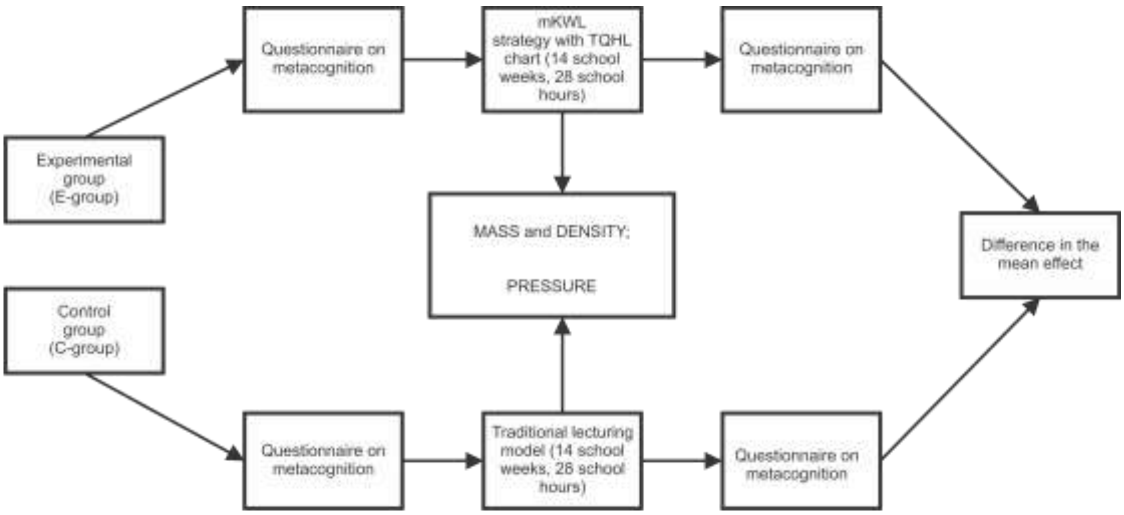

Figure 1 Research design

After equalising Groups E and C, students' metacognition in both groups was evaluated using a questionnaire on metacognition. After that, group E was taught the prepared two physics topics: (1) Mass and Density and (2) Pressure, by applying the mKWL strategy with the TQHL chart. The students in Group C were exposed to the same content using the common (traditional) teaching approach without the TQHL chart. Both topics were determined by the regular elementary school curriculum and included in total 12 teaching units.

The same teacher taught the same physics content to both groups in different classes. In Group E, the teacher gradually introduced the strategy. At first, the teacher asked the students to answer the columns and wrote their answers in a chart on the chalkboard. In that way the whole class was working together and the teacher was helping students with additional explanations and sub-questions. The next step was working in groups during which the teacher was again monitoring the students' work. After the students had been prepared for using the TQHL charts they started working individually in addition to group work. The TQHL charts were used for learning of the given teaching units and for homework. For classes, the teacher provided students with the opportunity to implement the inquiry they had chosen. For students' individual work during class (or for homework), the next class was dedicated to the analysis of the same teaching unit. Each chart was analysed and the whole class was included in the discussion about different questions, inquiries and conclusions. A student could additionally complete the L column if, after analysis, new information was adopted.

In the last physics class (no. 28) of the research, a questionnaire on metacognition (QMf) was again distributed among students, which they completed and returned to the teacher after the allocated 15 minutes.

Data Analysis

Raw scores on the questionnaire on metacognition (QMi and QMf) were treated statistically using the software package IBM SPSS Statistics 20 and Microsoft Office Excel. The first part of the analysis included descriptive statistics. Since QMi and QMf data proved to be normally distributed, which was confirmed by the obtained values of standardised skewness and standardised kurtosis (cf. Table 2) and by the results of the Shapiro-Wilk test of normality (QMi scores of the students in Group C: $W = .97$, $p = .19$, and in Group E: $W = .97$, $p = .12$), a paired sample *t*-tests were used to compare students' metacognition on the pre-test and post-test for Group E and Group C. Additionally, to compare the post-test scores (QMf) between students in Groups E and C, an independent sample *t*-test was used.

Results

The results of the questionnaire on metacognition are presented in Table 2, and figures are given in Appendix A and Appendix B. Table 2 shows standard statistical indicators for students' achievement (scores) on the questionnaire on metacognition before (QMi) and after introducing the experimental factor (QMf) for Group E and the same statistical indicators are shown for students in Group C.

As noted previously, normality can be assumed for this data set. According to the values of standardised skewness and kurtosis and Shapiro-Wilk normality test results, it is suggested that there is no deviation from normality within the groups. Therefore, to test the differences for statistical significance in the mean scores of parametric dependent variables, the two tests were used: paired sample *t*-test and independent sample *t*-test.

Firstly, it should be highlighted that students' scores in the questionnaire, both QMi and QMf, could range from 18 to 90 points. One can conclude from the students' metacognition scores on the questionnaire that higher scores denoted metacognition developed to a higher level. For example, as indicated in Table 2, the scores on the questionnaire on metacognition (QM) of Group E students were higher on QMf than on QMi – 4.61 points on average, which is a 6.4% higher mean score. To test the first hypothesis – that there was a significant difference in the results on the questionnaire on metacognition for Group E students before (QMi score) and after the experiment (QMf score) – the paired sample *t*-test was applied. This hypothesis can be accepted as true based on repeated results, as there was a significant difference in the QMf ($M = 76.2$, $SD = 6.48$) and the QMi ($M = 71.6$, $SD = 8.65$) scores for the students in Group E; $t(55) = -4.66$, $p < .0001$. At the same time, the test did not show a significant difference between the QMf ($M = 71.2$, $SD = 8.14$) and the QMi ($M = 72.0$, $SD = 8.07$) scores for the students in Group C; $t(53) = 1.99$, $p = .051$. Therefore, the second hypothesis of this research was also accepted as true. Additionally, it is interesting to note that 31 (of 56) students in Group C achieved higher scores on QMi than on the QMf, while only 15 (of 58) students in Group E achieved higher scores on the QMi than on the QMf (cf. Appendixes A and B). On the other hand, 36 students in Group E achieved higher scores on the QMf than on the QMi and only 11 students in Group C achieved higher scores on the QMf than on the QMi.

Furthermore, an additional independent sample *t*-test was performed to compare the QMi scores between the observed groups. As the results of the applied test show that there was no significant difference in QMi scores of the students in Group E ($M = 71.6$, $SD = 8.65$) and Group C ($M = 72.0$, $SD = 8.07$); $t(108) = .29$, $p = .77$, the third research hypothesis was accepted as being accurate.

In the end, the QMf scores between the students in Groups E and C were compared using an independent sample *t*-test. This test shows a statistically significant difference in the QMf scores of the students in Group E ($M = 76.2$, $SD = 6.48$) and Group C ($M = 71.2$, $SD = 8.14$), in favour of the students in group E; $t(108) = -3.50$, $p = .001$. Based on these results, the implication is that the mKWL strategy increases students' metacognition, and therefore, the fourth research hypothesis was accepted as being accurate.

Table 2 Basic descriptive statistics related to students' scores on QM

	Control group		Experimental group	
	QMi	QMf	QMi	QMf
N	54	54	56	56
M	72.0	71.2	71.6	76.2
Mdn	73.0	72.0	73.0	75.5
Mode	66[a]	63[a]	73[a]	75
SD	8.07	8.14	8.65	6.48
Coefficient of variation	0.11	0.11	0.12	0.085
Minimum	57	54	54	65
Maximum	87	88	87	88
Range	30	34	33	23
Standardised skewness	-0.27	-0.40	-0.76	0.82
Standardised kurtosis	-0.93	-0.47	-0.93	-1.22

Note. [a]Multiple modes exist. The smallest value is shown.

Discussion

The results obtained in this study indicate that students using the mKWL strategy with the TQHL chart in elementary school physics teaching showed a higher level of development of metacognition than students taught the same content using the traditional teaching approach without the TQHL chart.

According to the research results presented above, it could be said that the findings are in line with findings of similar studies. For example, while applying the KWL strategy with sixth-grade students, Tok (2013) found the positive effect of this metacognitive strategy on students' metacognition (i.e. metacognitive skills), and their mathematics achievement. Furthermore, conducting five case studies, Mok et al. (2006) showed that the KWL strategy had a positive effect on the self-assessment of teacher education students, promoting their metacognition. It was noted that while writing the KWL chart, participants must use metacognitive regulation, i.e., planning, information management, monitoring and evaluation. In that way, their metacognition is promoted throughout the learning process (Mok et al., 2006). In a study by Vijaya Kumari and Jinto (2014) it was shown that the KWL strategy can improve high school students' metacognition and performance. In a study by Özsoy and Ataman (2009), it was found that metacognitive strategy instruction using problem-solving activities significantly improved fifth-grade students' metacognitive abilities and skills of solving mathematical problems (Özsoy & Ataman, 2009). Zouhor, Bogdanović, et al. (2016) found that the KWL strategy improved sixth-grade students' metacognition, as well as physics performance. The benefits of the KWL strategy as metacognitive strategy have also been pointed out by Burns (1994), who showed that the KWL strategy improved learners' reading comprehension. Erawati (2012) also showed that the KWL strategy was a better metacognitive self-monitoring strategy than the Survey, Question, Read, Recite, and Review (SQ3R) with students reading any text types.

As is clear from the above, various authors refer to the KWL strategy as a metacognitive strategy and based on that it was expected that its modifications, such as the TQHL, could be used for improving metacognition. With the TQHL strategy, students were supported in activating their prior knowledge and including new concepts into their existing schemas. Furthermore, they were encouraged to think about their interest in the topic and also to propose and select the learning strategy (or method of inquiry). Another important advantage of implementing this strategy is reflecting on what the individual had learned and the identification of students' misconceptions. All of the above point to the fact that implementing the TQHL strategy directly contributes to students developing metacognitive awareness and use of metacognitive skills while learning. Particularly, students using this strategy are directed through metacognitive regulation. For example, they deal with information management while filling out the T and Q columns, planning while thinking of appropriate learning strategies or methods of inquiry (H column), summarising their findings and reflecting on what was learned (L column) leading them to evaluate their success in learning. Self-questioning, which is also included in the proposed TQHL strategy, is an important element of metacognitive strategies. While discussing TQHL charts in class, students became aware that there are many ways to learn the same content (one can find much information). This research results indicate that, since the purpose of implementing the TQHL strategy can be, among others, to promote metacognition, the proposed strategy can be considered as a metacognitive strategy.

The students in low-quintile South African schools who show low science and mathematics performance (indicated by Spaull & Kotze, 2015, cited in Stott, 2018), as well as low levels of general skills (indicated by Pretorius & Spaull, 2016) can benefit from using the TQHL strategy in class. The use of the TQHL charts can improve both students' science performance (Zouhor et al., 2017) and metacognition. The improvement of metacognition implies increasing learning skills in general and also a positive effect on the problem indicated by Van der Berg et al. (2016) of learners using time inefficiently. Moreover, based on research results, it can be suggested that the TQHL strategy is appropriate for physics teaching. The significance of that lies in the fact that this strategy, combined with others, provides teachers with new possibilities in teaching. Teachers having an available wide range of learning and teaching strategies can facilitate effective learning (Assan, 2019). This strategy is applicable and can be useful in physics education at an international level.

The results from the research provide answers to the research questions. However, some limitations of this research should be stated. Groups E and C were not selected completely at random because school classes were pre-constituted. The research included a sample of student of a particular age (only sixth grade) and no more than two physics topics were implemented. If the TQHL strategy would be used continuously (resulting with better prepared students to use it) then students could improve their metacognition (achieve higher scores on QM) even further.

Conclusion

The teaching content, Mass, Density and Pressure, was implemented by applying the mKWL strategy with the TQHL chart in Group E, while Group C was taught using the usual teaching approach without this strategy.

At the beginning of the experiment, before the TQHL chart was used in Group E, there was no significant difference between the result of students in Groups E and C (QMi score) on the questionnaire on metacognition. However, after introducing the experimental factor (the mKWL strategy with the TQHL chart) in Group E and using the traditional teaching approach with student in Group C, the significant difference in the results on the questionnaire on metacognition before (QMi score) and after the experiment (QMf score) was only found in Group E. Additionally, the significant difference in the QMf scores between the students in Groups E and C, in favour of Group E, was evident.

It can be concluded that students from Group E achieved better results in the questionnaire on metacognition than students from Group C, after the introduction of the mKWL strategy (with the TQHL chart) in Group E. The obtained results of this study indicate a higher level of development of metacognition within Group E students who applied this metacognitive strategy on physics learning. It can, therefore, be concluded that using the proposed mKWL strategy has a positive effect on sixth-grade students' metacognition as it increases students' metacognition. While using the TQHL charts, the prior knowledge of students in Group E was activated and applied to the new content. Furthermore, students started to think like scientists and carried out scientific inquiry in the physics classroom. Furthermore, teachers gained a better insight into students' thinking, understanding, and knowledge by using the TQHL chart.

A better understanding of the factors behind the learning process enables students to acquire physics content easier and one can point out the importance of metacognition as a supporting factor in the effective physics learning process. Based on the results of this study, the implications for both practice and further research can be given. Teachers should not only teach students about the prescribed topics but about using useful learning strategies as well. The implication for practice: while teaching physics content, teachers should also help students to establish a habit of self-checking their understanding and task approach, and related metacognitive knowledge should also be imparted. Students with poor metacognition may benefit from metacognitive training to improve their metacognition and cognitive performance. Although the positive impact of metacognitive strategies on the students' metacognition was detected, they are not sufficiently represented in school practice today. The reasons for this are numerous, but the most important is the lack of teacher training for their implementation. In order to improve physics teaching by using the mKWL strategy with the TQHL chart, it is necessary to provide training for teachers. Further training of teachers and students is planned for the implementation of this strategy as well as providing adequate resources. Moreover, it will be advisable to present findings of positive effects of the implementation of metacognitive strategies to teachers in order to raise awareness of the necessity to undergo appropriate teacher training. Thus, the positive aspects of implementing the mKWL strategy will be disseminated to other schools. The intention is that in future, it becomes the usual teaching strategy in elementary schools in the Republic of Serbia and also to initiate its implementation internationally. The teachers and staff should be gradually trained for the application of this teaching strategy.

Based on these research results, the direction of future studies can be proposed. We propose that further research regarding this topic included not only broader physics teaching content, but also content from other school subjects and different grade levels. Future research may be carried out with an estimation of metacognitive strategies in use. This would further enhance understanding of the extent to which individuals vary in physics learning efficiency related to metacognitive ability as well as their awareness of it, and that would have important implications for the teaching of physics. It would be interesting to examine other variables when the mKWL strategy is implemented, as well as students' metacognition when different teaching and learning strategies are used.

Authors' Contributions

IZB wrote the manuscript; JDS edited the manuscript and assisted with the literature review; DDR and TNR analysed the data and assisted with the formulation of the conclusion; ZAMZ prepared the research instruments. All authors conceptualised the study and reviewed the final manuscript.

Notes

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ii.
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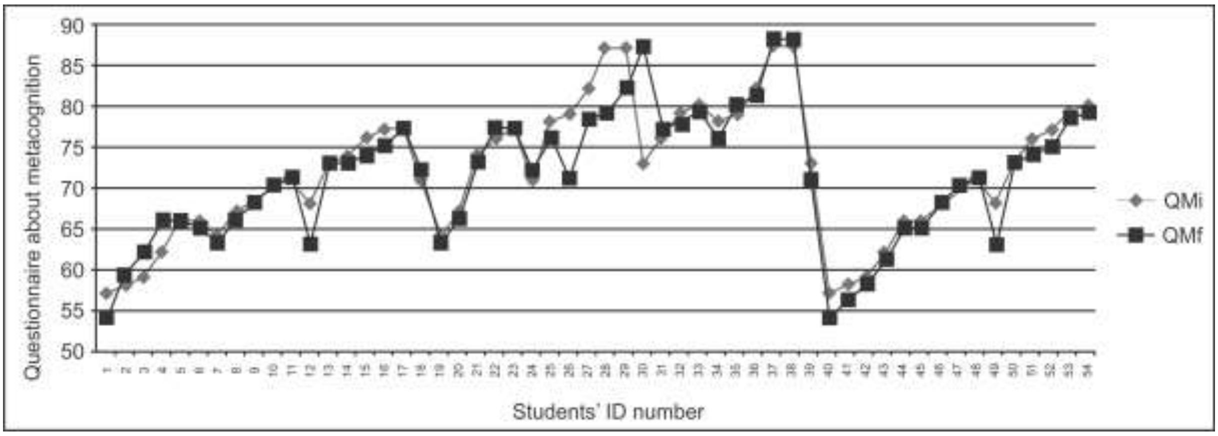
Appendix A: Graph for the QMi and QMf scores of the control group



Appendix B: Graph for the QMi and QMf scores of the experimental group