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THE EFFECTS OF MODIFIED KNOW-WANT-LEARN STRATEGY IN MIXED-GENDER LOWER SECONDARY PHYSICS EDUCATION

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Abstract. *The differences related to gender are evident in physics education from the early age of the students. Thus, it is important that the teaching strategies that are implemented in mixed-gender physics classrooms are appropriate for both boys and girls. This research examined physics achievement and metacognitive awareness of students in lower secondary education in relation to gender when the modified Know-Want-Learn (mKWL) strategy is implemented. During the study, the students were divided into the control group (where direct teaching was implemented) and the experimental group (where the mKWL strategy was implemented in physics teaching). Students' physics achievement (estimated with knowledge tests) and metacognitive awareness (estimated with a questionnaire) before and after the pedagogical experiment, and also the students' comments on the mKWL strategy (provided through an informal conversation) were analyzed. It was shown that the students' achievement did not differ in relation to gender while girls showed higher metacognitive awareness in comparison with boys, and the mKWL strategy increased physics achievement and metacognitive awareness of both boys and girls. Furthermore, the students' comments on the strategy were discussed. The proposed strategy is shown to be appropriate for both genders, and its implementation in physics classrooms can be recommended.*

Keywords: *metacognitive awareness, physics education, quasi-experimental research, students' achievement, students' comments*

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Introduction

Physics is a natural science, and its concepts and laws can be seen in everyday phenomena and situations, so students have experiential knowledge about physics content. Regarding its foundation one can point out inquiry (e.g., experimental) results, criticisms, and rational discussions. Accordingly, physics as a school subject provides many different opportunities for teaching. The main goal of science education is raising scientific literacy (Demkanin, 2013). According to Demkanin (2018), only a teacher trained in knowledge, abilities, and relationships can teach physics successfully and make classes enjoyable for the teacher and the students. Teachers should be trained to use different teaching strategies that are proven to be appropriate and useful in physics class. Thus, the evidence on the possibilities of a particular teaching strategy can facilitate physics education. Direct teaching which is most often used has its limitations in contemporary education, especially in physics classrooms (Buabeng et al., 2014). Students achieve their full potential in physics only if their teachers use teaching strategies appropriate for given content and situation (Borich, 2007). If a variety of teaching strategies is available to the physics teacher, the most appropriate strategy can be implemented for each lesson. When evaluating the suitability of a particular strategy, one should consider that along with physics knowledge and scientific literacy, the students' metacognitive awareness should be developed during physics teaching.

Another important source of concern for science educators is the low number of female physicists. Nowadays, mixed-gender schools are the most common in many cultures around the world. Since the differences in relation to gender can arise in early physics education, the problem that physics teachers face today is how to teach students of both genders efficiently. This problem is not unique to physics but generally exists in other branches of science. Using particular teaching strategy that helps students in acquiring physics knowledge and developing metacognition should be appropriate for all students (boys and girls).

Contradictory findings can be found in the literature when it comes to student achievement in relation to gender. While some researchers found that

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students' physics achievement did not differ in relation to gender (for instance, Sorge, 2007; Spelke, 2005), others showed that gender differences in students' physics achievement existed in favor of boys (Madlazim & Husnaini, 2019), or girls (Bursal, 2013). A possible reason for these contradictory findings can be found in the application of different teaching strategies. For instance, Hazari et al. (2007) found that, for both genders, previous affective experiences and physics education along with mathematics preparation, predict university physics achievement.

Metacognition is considered an important aspect of learning. It refers to one's "cognition about cognition" and it comprises metacognitive knowledge (e.g., awareness of personal involvement in cognitive processes and knowledge about these processes), metacognitive regulation (regulation of cognition by various activities, such as planning, monitoring and evaluating of the cognitive processes, and others) and metacognitive experiences (one's feelings and judgments related to cognitive processes, e.g., feeling of knowing) (see, e.g., Bogdanović et al., 2021; Efklides, 2006). Students' readiness for working independently and flexibly is conditioned by students' metacognition (Rahman, 2011). Therefore, metacognition is an important prerequisite for students' high achievement. It can be described as person's knowledge and ability to monitor the cognitive processes (Cross & Paris, 1988; Flavell, 1976). If students' metacognition is at high level, they are considered efficient learners; they acquire the long-lasting knowledge and they are successful in generalizing (Ahmadi et al., 2013). Furthermore, these students believe that they can be successful, they are reflecting on their learning and evaluating their success, and they identify and adjust learning strategies appropriate for given tasks (Rahman et al., 2010). Students' physics achievement can be positively affected by the implementation of particular metacognitive strategies at various educational levels (Bogdanović et al., 2015; Gok, 2010). Since teaching in a teacher-centered manner, e.g., direct teaching that is traditionally being used does not encourage students to think and implement metacognitive strategies (Cadle, 2010), teaching efficiency can be improved by the implementation of teaching with the use of metacognitive strategies (Fouché & Lamport, 2011). Various researchers found that metacognition is gender dependent, and in many studies girls showed higher metacognitive ability than boys (Singh, 2012). Still, some studies have shown the opposite. In addition to the applied teaching strategy as a possible cause, inconsistency in the findings of various studies may also be due to the difference in the age of the students. Based on this, the selection of a metacognitive strategy appropriate for the entire class (boys and girls) is of great importance.

Know-Want-Learn Strategy and its Proposed Modification

The implementation of the Know-Want-Learn strategy (hereinafter referred to as KWL) was first designed to help students work on the text, but it later proved to be the same efficient as a learning strategy, compatible with different learning materials, and also efficient as a metacognitive strategy (Foote et al., 2001; Kumari & Jinto, 2014). This strategy leads students to fill the KWL table, not just during, but also before and after learning, which helps them to better organize their knowledge.

In the first (K – "What I Know") column of the KWL table, each student should state the facts that he/she is already familiar with in regard to the given topic. The purpose of this phase is to activate students' prior knowledge. Namely, while writing questions about the topic in the second (W – "What I want to know") column, students' interest is being stimulated. Finally, after learning is realized, students are reviewing what is learned while filling the third (L – "What I learned") column.

The KWL strategy is appropriate for students' inquiry (Ogle, 2009) and it can be implemented as a whole-class activity or individually (Tok, 2013). The implementation of this strategy is beneficial because it: activates students' prior knowledge (Martorella et al., 2005); encourages active learning and increases students' achievement (Tran, 2015); helps students to recognize the reading goal and improve skills required to monitor their learning process successfully (Szabo, 2006); and increases reading comprehension (Al-Khateeb & Idrees, 2010). Accordingly, one can recognize that students are being led to carry out various metacognitive activities.

The KWL strategy can be modified and adjusted for different learning activities. It can be achieved by adding new and modifying existing columns (see, e.g., Akerson, 2001; Crowther & Cannon, 2004; Hershberger et al., 2006; Ogle, 1987; Weaver, 1994). Using various modifications of KWL strategies can be useful for students' inquiry. In this research a new modification of the KWL table is proposed – the TQHL table. The TQHL table is proposed following the example of KWL table (Ogle, 1986) and THC table ("What do you think"; "How can we find out"; "What do we conclude") table (Crowther & Cannon, 2004).

This modification is proposed to initiate the activation of previous knowledge and experience and lead students to express their opinions on a particular topic. Accordingly, the first modified table column is proposed as: "What

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I think and what I know" (T column). A slightly different formulation of the second table column, "What questions I have" (Q column), directs students to define problems and propose a hypothesis for an inquiry on their own. The third table column "How can I find out" (H column), encourages students to propose activities that they find appropriate for performing inquiry. After learning, students are reviewing newly acquired knowledge in the column "What I learned" (L column). The TQHL strategy is described in detail in previous researchers' work (Bogdanović et al., 2021; Zouhor, 2018; Zouhor et al., 2017).

Research Problem

Physics education is often oriented towards the acquisition of content knowledge, and it is not nurturing students' metacognitive awareness. Besides, many studies showed that boys and girls learn differently with gender differences found in cognitive functioning (Downing et al., 2008; Singh, 2012). The study carried out in 14- and 15- years old students and science teachers indicated the differences between preferences about the teaching practices of boys and girls (Oliveira et al., 2018). Similarly, Kulturel-Konak et al. (2011) stated that the barrier encountered by women in physics derives from teaching methods favoring a learning style that is not preferred by girls; because of that, the gender gap in STEM fields persists. The atmosphere developed in education supports one learning mode while dismissing others (Kolb & Kolb, 2005) and direct teaching suits boys' learning preferences (Philbin et al., 1995). For instance, Lorenzo et al. (2006) showed that when students were taught using interactive strategy, the difference in physics content comprehension at the university level related to gender was reduced.

Taking into account the gender differences in early education, such as physics class in lower secondary education, is beneficial because it is shown that career aspirations are being formed mostly by 13 years and consequently, in older age, engaging students in science becomes difficult (Lindahl, 2007). Girls' career aspirations and interest in science should be mostly encouraged between the ages of 10 to 14 (Archer et al., 2013). If the teachers are aware that boys and girls have different opinions about science, as well as preferences about both teaching and learning practice, it is expected that they employ specific teaching strategies to address these issues. Moreover, Hofer et al. (2018) concluded that the teachers could implement appropriate "cognitively activating methods" for reducing gender differences in physics. Accordingly, it is desirable to identify teaching strategies for science classes, as physics, which are appropriate for students of both genders and also increase students' achievement as well as metacognitive awareness.

Research Aim and Questions

The purpose of this research was to explore whether students' physics achievement and metacognitive awareness depend on gender in regard to using the proposed strategy in lower secondary education and to summarize the students' comments on the strategy. The following research questions were addressed:

- Is students' physics achievement dependent on gender when (1) the direct teaching is implemented and (2) the mKWL strategy is implemented?
- Can the implementation of the mKWL strategy improve physics achievement of boys?
- Can the implementation of the mKWL strategy improve physics achievement of girls?
- Is students' metacognitive awareness dependent on gender when (1) the direct teaching is implemented and (2) the mKWL strategy is implemented?
- Can the implementation of the mKWL strategy improve boys' metacognitive awareness?
- Can the implementation of the mKWL strategy improve girls' metacognitive awareness?
- How did the students perceive the implementation of the mKWL?

Research Methodology

Research Design

This analysis is a part of a comprehensive study that was set out to implement the mKWL strategy with the use of TQHL tables. This research direction was the logical sequel of the previous authors' work in which the impact of TQHL tables implementation in physics classes on students' achievement (Zouhor et al., 2017) and metacognitive awareness (Zouhor, 2018), and also their correlation (Bogdanović et al., 2021) were analyzed. After the positive ef-

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fects of the strategy on students' achievement and metacognitive awareness were shown, the question of whether the strategy is equally appropriate for both boys and girls remained to be addressed in order to strongly suggest that the strategy is useful for mixed-gender classes.

The researchers performed quasi-experimental research for 14 consecutive school weeks (from the beginning of March to the end of June in 2017). For all students who participated in the research, the pre-testing was performed in order to measure students' physics achievement and metacognitive awareness. Considering students' scores on the pre-test, experimental (E) and control (C) groups were formed. The direct teaching, that is explicit teaching through lectures, teacher-led demonstrations and computational physics problems, was used for delivering physics lessons in the group C, while the above-mentioned mKWL strategy with the use of TQHL tables was used for delivering physics lessons in the group E. During the research, both groups were taught the same teaching units on the same topics: Mass and Density, and Pressure. Afterwards, the post-testing was performed for measuring students' physics knowledge and metacognitive awareness.

Study Sample

The study was carried out with the students of lower secondary education in the Republic of Serbia. Participants were students attending five classes in the sixth grade of the selected school. Since it was decided that all classes in the study sample should be taught by the same physics teacher to reduce "the teacher effect", the study sample was limited to 141 participants. Although, there is no certain procedure to avoid teacher bias when implementing different teaching strategies during the research, according to Özmen et al. (2009) if more than one teacher is involved in the research, it adds variations influencing the research results. Further, this sample was selected based on the long-term cooperation in previous studies between the researchers and the physics teacher employed in the selected school. The teacher willingly participated in the research. Since the innovative KWL strategy was proposed and implemented for the first time in the research, it was necessary that the teacher included in the research was additionally trained for the implementation of the mKWL strategy. The researchers met with the teacher before the beginning of the research to ensure that he was prepared to implement the proposed strategy. The teacher understood the significance of all the columns in the TQHL table as well as how these tables could be introduced in classes. The researchers and the teacher stayed in contact during the research.

Based on the results of the pre-test, one class was excluded from further research in order to equalize two groups (E and C) before the introduction of the experimental factor. After excluding that class, 110 students remained in the pedagogical experiment (of which 51 were boys and 59 were girls). Group C consisted of two classes (that included 54 students), while group E consisted of two other classes (that included 56 students). All students included in the study have accepted to voluntarily take part in the study with the possibility to leave the study at any stage. The parents, teachers, and school administration were informed about the study and their consent was obtained prior to research. Data collection was carried out anonymously to ensure participants' privacy. This also ensured that students reply sincerely to the questionnaire on metacognitive awareness which recorded self-reported data.

Instruments and Procedure

Data were collected using instruments developed for the purpose of this research: (1) physics knowledge pre-test (PKTi), (2) physics knowledge post-test (PKTf), and (3) a questionnaire on metacognitive awareness. The physics knowledge tests consisted of 12 items each. Based on the difficulty of the given tasks, each task was scored with one, two or three points. The value of Cronbach's alpha coefficient for the PKTi was .74 and for the PKTf .68. On the basis of these values, it can be concluded that the reliabilities of both the PKTi and PKTf were acceptable. According to the suggestion given by Segedinac et al. (2011), the content validity of tests was evaluated by the expert team with appropriate competencies (two physics teachers in lower secondary education, a school pedagogue – employee of Serbian schools who is assisting teachers by advising them about teaching, if needed, and an assistant professor in Physics education). As declared by the expert team both the PKTi and PKTf were valid: the sixth graders could easily understand items and all tasks were precisely formulated; covered content was in line with the school curriculum, as well as the physics textbooks). The students were assigned to fill in each test in 45 minutes (a class hour). A questionnaire on metacognitive awareness was an adaptation of Junior Metacognitive Awareness Inventory (Jr. MAI) for children up to 14 years (created and valuated by Sperling et al., 2002). The questionnaire included 18 items with a 5-point Likert scale; the metacognitive knowledge and regulation were covered

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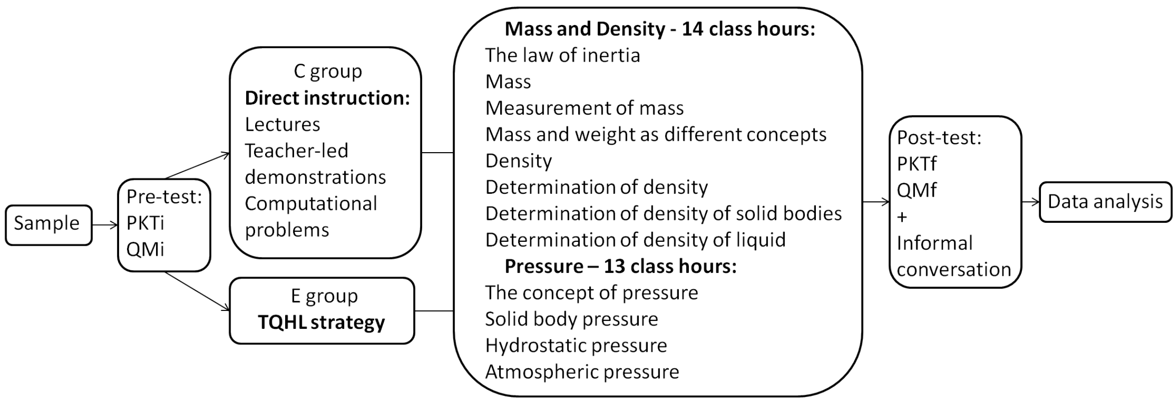
by the questionnaire. Students should evaluate given statements in the range from "strongly disagree" to "strongly agree". The value of Cronbach's alpha coefficient of .70 indicates satisfactory reliability of Jr. MAI. The questionnaire on metacognitive awareness was administrated at the beginning of the pedagogical experiment (in the first class in which the students were explained about the study) (QMi) and again after the experiment (QMf). The students had 15 minutes to complete the QMi, and the same for the QMf. Additionally, in order to collect data on students' perception about the implementation of the mKWL strategy, the teacher had an informal conversation with the E group students after the research.

Groups C and E were equalized based on the evaluation of students' achievement and metacognitive awareness. During the study, the same teacher was engaged in physics classes for the C and E group. The teacher and the research team prepared lessons and teaching material together and they were constantly communicating to ensure the successful implementation of the strategy. In the group E, the teacher first explained the TQHL tables to the students and, together with the students, filled the table for the planned teaching unit. The teacher suggested how particular columns could be filled and the students were giving their ideas. After the students became trained for the implementation of the mKWL strategy, they continued using it. The strategy was implemented as a whole-class activity, in group work, or individual work. The teacher directed the students to use this strategy also at home for learning given physics teaching units. During that time, the C group students were taught the same teaching units for the same time period using teachers' lectures, demonstrations and computational physics problems (Figure 1).

Figure 1
Schematic Presentation of Research Procedure



Data Analysis

Before conducting other statistical tests, the normality of the distribution of the gathered data was estimated by calculating standardized values of skewness and kurtosis, and performing the Shapiro-Wilk test. The differences between the PKTi and the PKTf and the QMi and the QMf in relation to gender were explored using an independent-samples *t*-test (separately for groups E and C). Additionally, the comparisons of students' scores on the PKTf and the PKTi and also on the QMf and the QMi scores were carried out by performing a paired-samples *t*-test. Besides, for both groups values of average normalized gain (*n*-gain) were calculated for boys and girls. The *n*-gain was calculated as proposed by Hake (1998), the value of reached average gain expressed in percent is divided by the maximum possible average gain expressed in percent. Additionally, qualitative analysis of data is carried out on students' perception of the implementation of the mKWL strategy.

Research Results

Students' Achievement in Physics in Relation to Gender

Students' physics achievement was estimated based on the sum scores on the PKTi and PKTf. These scores could be in the interval from minimal 0 pt. (if none answer is correct) to maximal 20 pt. (if all answers are correct).

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Furthermore, since standardized values of skewness and kurtosis were between -2 and 2 and only for the group E, the PKTf scores for the boys, the Shapiro-Wilk test showed *p*-value below .05, the assumption about normal distributed data is made (Table 1).

Table 1
Estimation of Data Normality for the PKT Scores

Test	Gender	Shapiro-Wilk			Standardized Skewness	Standardized Kurtosis
		W	*df*	*p*		
PKTi – group C	Boys	.95	25	.21	-0.40	-1.17
	Girls	.95	29	.22	0.37	-1.14
PKTf – group C	Boys	.95	25	.32	-0.90	-0.69
	Girls	.96	29	.31	0.08	-1.09
PKTi – group E	Boys	.97	26	.60	0.71	-0.48
	Girls	.95	30	.17	0.54	-1.20
PKTf – group E	Boys	.91	26	.03	-1.54	-0.27
	Girls	.96	30	.30	-0.85	-0.65

The independent-samples *t*-test was performed for comparing the boys' PKTi and PKTf scores and the girls' PKTi and PKTf scores. In both groups, the boys' PKTi scores did not differ from the girls' PKTi scores and also the PKTf scores of boys and girls did not differ (Table 2).

Table 2
Independent-Samples t-test Comparing the PKTi and the PKTf Scores of the Boys and the Girls

Group	Test	Gender	*M*	*SD*	*t*	*df*	*p*
Group C	PKTi	Boys	10.2	4.01	-.75	52	.45
		Girls	11.1	5.04			
	PKTf	Boys	10.8	3.94	-.55	52	.58
		Girls	11.5	4.96			
Group E	PKTi	Boys	9.81	4.28	-.21	54	.83
		Girls	10.1	4.78			
	PKTf	Boys	15.19	4.08	1.901	54	.063
		Girls	13.10	4.13			

The scores on the PKTi and the scores on the PKTf were compared using a paired-samples *t*-test. This test was performed for each group separately: girls in the group C, boys in the group C, girls in the group E and boys in the group E.

The PKTi scores did not differ significantly from the PKTf scores for boys as well as girls in the group C. At the same time, in the group E, the difference was shown between the boys' PKTi scores and PKTf scores, and also the difference was shown between the girls' PKTi scores and PKTf scores. Students of both genders gained higher PKTf scores compared to PKTi scores (Table 3).

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Table 3

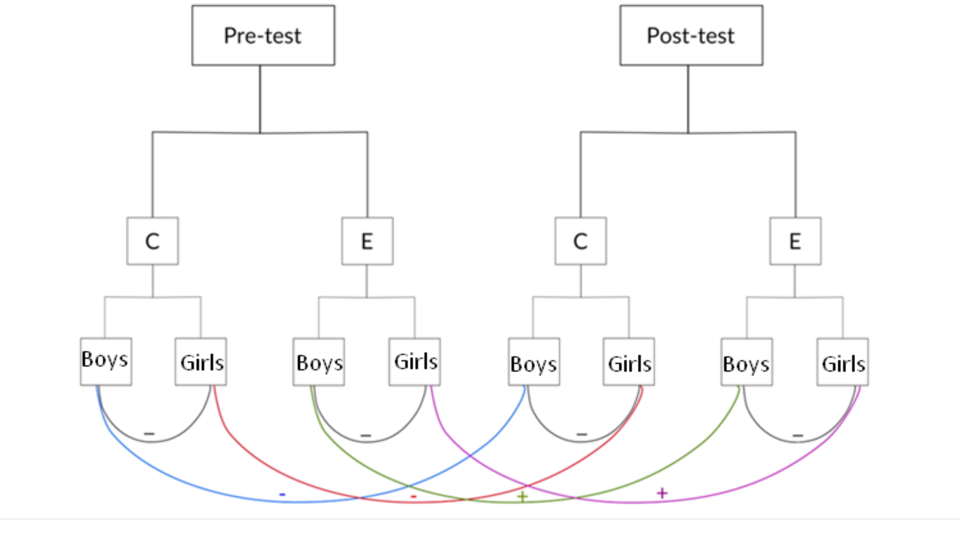
Paired-Samples t-test Comparing the PKTi and the PKTf Scores of Boys/Girls and n-gain

Group	Gender	Test	*M*	*SD*	*t*	*df*	*p*	*n-gain*
Group C	Boys	PKTi	10.2	4.01	-.55	24	.59	.065
		PKTf	10.8	3.94				
	Girls	PKTi	11.1	5.04	-.31	28	.76	.043
		PKTf	11.5	4.96				
Group E	Boys	PKTi	9.81	4.28	-4.06	25	.000	.53
		PKTf	15.2	4.08				
	Girls	PKTi	10.1	4.78	-2.74	29	.010	.31
		PKTf	13.1	4.13				

Based on the *n*-gain values in groups E and C, the implementation of the mKWL strategy proved to have positive effect on physics achievement of both boys and girls in the E group. In accordance with the criteria set by Hake (1998), for E group students the values of *n*-gain were moderate for students of both genders. The summarized results can be represented by a scheme (Figure 1).

Figure 1

The Differences in Students' Physics Achievement



\+ meaning the difference is statistically significant
\- meaning the difference is not statistically significant

Students' Metacognitive Awareness in Relation to Gender

Higher sum scores on the questionnaire on metacognitive awareness (where possible values could be in the interval between 18 and 90 points) denoted students' metacognitive awareness at a higher level. The normal distribution was assumed for all data groups concerning students' metacognitive awareness (Table 4). This assumption was made on the basis that the standardized skewness and kurtosis were found to be between -2 and 2. Besides, the Shapiro-Wilk test showed that the only exception with *p*-value slightly below .05 was the QMf in group E for the boys.

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Table 4
Estimation of Data Normality for the QM Scores

Questionnaire	Gender	Shapiro-Wilk			Standardized Skewness	Standardized Kurtosis
		W	*df*	*p*		
QMi – group C	Boys	.94	25	.20	-0.84	-0.84
	Girls	.94	29	.14	-1.01	-0.66
QMf – group C	Boys	.94	25	.18	-1.10	-0.33
	Girls	.96	29	.30	-1.02	-0.44
QMi – group E	Boys	.98	26	.88	0.36	-0.23
	Girls	.93	30	.07	-1.74	0.23
QMf – group E	Boys	.92	26	.04	1.45	-0.57
	Girls	.96	30	.24	0.53	-0.69

Independent-samples *t*-test was performed to compare the QMi and QMf scores of the boys and the girls. In both groups (E and C), the QMi scores, as well as the QMf scores of the girls, were shown to be higher than the corresponding scores of the boys (Table 5).

Table 5
Independent-Samples t-test Comparing the QMi and the QMf Scores of the Boys and the Girls

Group	Test	Gender	*M*	*SD*	*t*	*df*	*p*
Group C	QMi	Boys	69.2	6.26	-2.48	52	.017
		Girls	74.4	8.75			
	QMf	Boys	68.8	6.15	-2.06	52	.045
		Girls	73.3	9.15			
Group E	QMi	Boys	68.6	7.86	-2.45	54	.017
		Girls	74.1	8.63			
	QMf	Boys	74.2	6.94	-2.16	54	.035
		Girls	77.9	5.64			

The QMi and QMf scores were compared within each group of data separately (girls in the group C, boys in the group C, girls in the group E and boys in the group E) by using a paired-samples *t*-test. According to the gained results, for both genders the QMi scores did not differ from the QMf scores in the group C. However, for students of both genders in the group E it is shown that the QMf scores were significantly higher than the QMi scores (Table 6).

Table 6
Paired-Samples t-test Comparing the QMi and the QMf Scores of Boys/Girls and n-gain

Group	Gender	Test	*M*	*SD*	*t*	*df*	*p*	*n*-gain
Group C	Boys	QMi	69.2	6.26	1.11	24	.28	-.019
		QMf	68.8	6.15				
	Girls	QMi	74.4	8.75	1.69	28	.10	-.075
		QMf	73.3	9.15				

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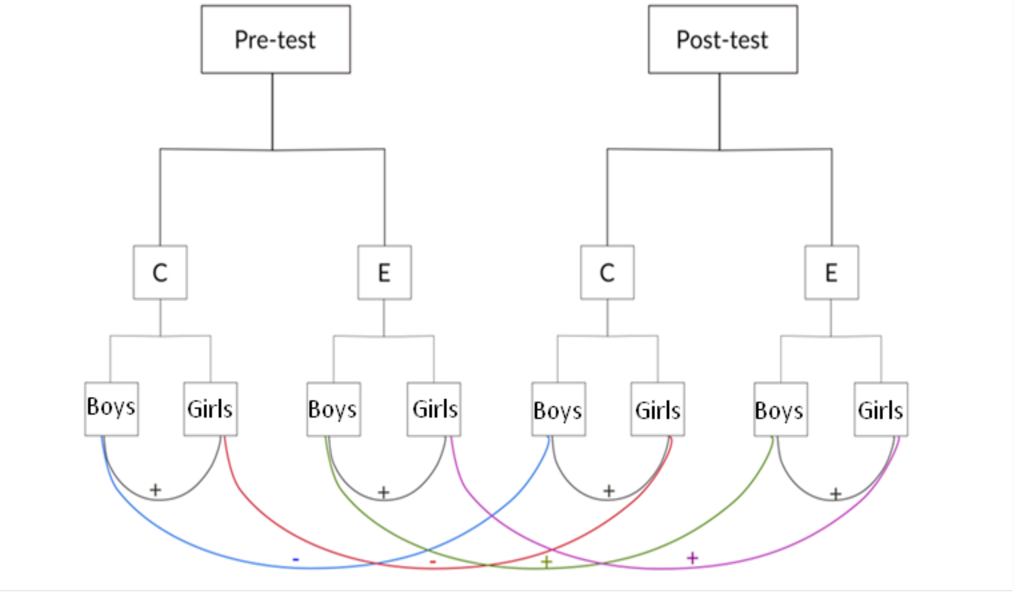
Group	Gender	Test	*M*	*SD*	*t*	*df*	*p*	*n*-gain
Group E	Boys	QMi	68.6	7.86	-3.80	25	.001	.26
		QMf	74.2	6.94				
	Girls	QMi	74.1	8.63	-2.80	29	.009	.24
		QMf	77.9	5.64				

The comparison of *n*-gain values in groups E and C indicated that the implementation of the proposed strategy had a positive effect on metacognitive awareness of both boys and girls. For the E group students, *n*-gain was found to be in the category of low *n*-gain (according to the categorization by Hake, 1998) for both boys and girls. The summarized results about students' metacognitive awareness can be represented by a scheme (Figure 2).

Figure 2
The Differences in Students' Metacognitive Awareness



\+ meaning the difference is statistically significant
\- meaning the difference is not statistically significant

Students' Comments on the Implementation of the TQHL Strategy

In one school hour after the pedagogical experiment, in order to get additional feedback on the TQHL strategy, in an informal conversation, the physics teacher asked the E group students three questions about the implementation of the strategy. The teacher was asking the questions, and the students who wanted to give their answers were raising their hands and each of them was given the opportunity to answer. On each question, about 60% of the students answered. The teacher took notes about the responses of the students.

The first question was about positive and negative aspects of the implementation of the TQHL strategy. About 50% of the students commented on the positive aspects and only 10% of the students commented on the negative aspects. Some students' comments about positive aspects of the strategy are listed here:

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- "The physics classes were much more fun when we used the TQHL strategy."
- "The TQHL table reminds me what to do in order to learn something easily."
- "I am using the same strategy to learn other school subjects."

About the same number of students supported each of these comments. There was a similar distribution of students with different physics marks related to each comment, and there were no differences related to students' gender. The students' comments about negative aspects of the strategy were as follows:

- "We had more homework than usual."
- "We did fewer computational problems than before."

Regarding these comments, the difference in opinions of students with high and low achievement was observed: the first comment was supported by low achievement students and the second was supported with high achievement students. There were no differences related to students' gender.

The second question was about the usefulness of each column separately; the students were asked to evaluate which column is the most useful and which is the least useful. The students (approximately 60%) singled out the T and L columns as the most useful, these two columns were equally represented in students' answers and there were no differences related to students' achievement and gender. Based on students' comments it could be noticed that the students have recognized that the T column is important because they needed to use prior knowledge in most lessons. Besides, after completing the L column they experienced the feeling of knowing and it strengthened their self-confidence. Several students singled out the Q column as the least useful, because as one student stated: "*Students' questions are not useful for learning. It is important what questions will the teacher ask*".

The third question was about the difficulty of filling in each column of the TQHL table. Several students singled out the H column as the easiest because if they were without other idea, they could select the Internet as the source for learning. About 60% of students could not single out any column as easy, and also could not single out one column as the most difficult. Three columns, the T, Q and L, are recognized as difficult. All three were equally represented in students' comments as difficult and there were no differences related to students' achievement and gender. Students' explanation was that they did not have ideas, they needed to think for a long time in order to feel in these columns. With the aim of evaluating the implementation of the TQHL strategy, the teacher took notes about students' activities during the research. He observed that the most students in the E group were willing to actively participate in most teaching units.

Discussion

The number of previous studies have shown that students' achievement in science does not differ in relation to gender (e.g., Goldin et al., 2006; Sorge, 2007; Spelke, 2005). However, there are also studies that have shown otherwise. Various studies have shown that boys achieved better students' achievement in science than girls (Evans et al., 2002; Nosek et al., 2009). Hedges and Nowell (1995) have shown that the boys outperformed the girls when it comes to mathematics and science disciplines. In the same study it was shown that when it comes to language and arts, the girls showed higher achievement than the boys. According to Hsin-Hui (2015) the boys showed higher achievement than the girls in science starting in third grade, while according to Bursal (2013), in grades fourth to eighth, the girls performed better than the boys, as the grade level increased the difference was greater, and also Serin (2010) showed that the achievement in science of girls was higher than the achievement of boys.

Because of the differences that boys and girls express about the teaching practices (Oliveira et al., 2018), it can be suggested that different findings of gender differences regarding students' science achievement may be due to the application of different teaching strategies in science classes. For instance, Mierdel and Bogner (2019) carried out research in Bavaria and suggested that a hands-on module combining experimental and creative model work (implemented for teaching DNA structure) can attract girls to science. In research carried out in Taiwan, it is shown that the girls' achievement (in the course of digital video clips) is higher than the boys' achievement when project-based learning is implemented (Liao et al., 2018).

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Regarding dependence on gender of metacognition, the same as for science achievement, the findings are inconsistent. Many researchers have indicated that the girls had more developed metacognition than the boys of the same age (Bogdanović et al., 2015; Singh, 2012). However, there are also findings opposing the above stated. The number of researchers found that there is no gender-related difference in metacognition (Topçu & Yilmaz-Tüzün, 2009; Zhu, 2007), or that the boys had higher metacognition (in relation to implementation of appropriate learning strategies) than the girls (Niemivirta, 1997).

It is possible that the gender differences in metacognition are varying due to the difference in the age of students, thus the findings of various studies are inconsistent because students of different ages were included in the studies. For instance, in the research carried out in Swiss high schools, Leutwyler (2009) showed the higher level of metacognition of girls and also that gender differences in some metacognitive abilities had a tendency of equalizing during high school, while the difference in the ability of planning remained. Another factor that can lead to gender differences in students' metacognition is implemented teaching strategy. Consequently, exploring the effects of a particular teaching strategy on students' metacognition is of great importance.

In this study it is shown that, in both the C and E groups, students' physics achievement did not differ in relation to gender (Table 2). However, in both the C and E groups, gender difference exists related to students' metacognitive awareness, the girls had shown higher metacognitive awareness (Table 5). There was no significant difference between the PKTi and PKTf, and also there was no significant difference between the QMi and QMf in the C group, the same is shown for both genders. This is easy to explain because the students were being taught in the same manner as before. On the other hand, in accordance with the results obtained for the E group, one can suggest that for the students of both genders, the implementation of the mKWL strategy enhanced both students' achievement in physics (Table 3) and metacognitive awareness (Table 6). Based on the increase from the PKTi to the PKTf, and from the QMi to the QMf for the E group students (both boys and girls), it can be expected that the boys and girls using the mKWL strategy would get higher physics marks and it would result in better students' achievement. This was expected since the mKWL strategy encourages activating students' prior knowledge (T column), enhancing students' interest (Q column), stimulating students' inquiry (H column) and promoting summarizing lessons (L column) (Zouhor, 2018). What is stated here also indicates the importance of each column in the TQHL table for improving learning and, simultaneously encouraging students' metacognition which also facilitates learning. The study showed that the E group students became aware of some positive aspects of the TQHL strategy and usefulness of the T and L columns separately, and at the same time they perceived even three columns (T, Q and L) as difficult. These results on students' perception of the TQHL strategy indicated that although they have generally recognized the positive aspects of the strategy, they did not recognize the importance of the Q and H columns and did not become skilled in the implementation of the strategy. Accordingly, the need to pay additional attention to preparing students to implement the strategy can be pointed out.

Although the research questions were successfully answered, this research had potential limitations. The main limitation is that the research sample consisted of participants who were grouped in pre-constituted classes and only sixth-grade students were included. Besides, during the pedagogical experiment, just two physics topics were delivered to the students.

Conclusions and Implications

Teaching physics in mixed-gender lower secondary education (as a standalone subject or within science) is quite challenging and similar issues are recognized in many countries worldwide. Accordingly, dealing with these issues is of international interest. Some of the main problems are students' low achievement, the acquisition of inapplicable physics knowledge and boys and girls who do not perceive physics classes in the same way. Great efforts must be made by researchers and teachers to reduce and finally overcome these problems. Apart from possible major educational reforms in the future, it is useful to start by finding different teaching strategies that can be easily implemented in everyday school practice and make a difference.

This study was carried out to explore whether physics achievement and metacognitive awareness of sixth graders depend on gender with respect to using the mKWL strategy and how students perceive the implementation of the strategy. For the students in the E group the mKWL strategy was implemented in physics teaching, while in the C group the direct teaching was implemented.

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It was shown that students' achievement did not depend on gender, while the girls showed higher metacognitive awareness in comparison with the boys. For all students (boys and girls equally), the implementation of the mKWL strategy increased both physics achievement and metacognitive awareness. The students recognized some positive aspects of the implementation of the strategy and usefulness of the T and L columns separately, while they found that even three columns (T, Q and L) were difficult for filling in. One can notice that the students did not recognize the importance of the Q and H columns, the reason for that was probably the fact that students' interest and students' ideas were not nurtured through education, so the students did not find them important. Besides, based on the E group students' comments given in an informal conversation, it can be suggested that the students of both genders found that the proposed strategy was useful and interesting. Nevertheless, the students perceived particular columns as difficult, which may be due the practice that the students are used to: the teacher asking specific questions and the students memorizing and reproducing the specific content. It can be indicated that the implementation of the mKWL strategy with the use of TQHL table can be helpful for students mastering physics content and can also increase metacognitive awareness, and the proposed strategy is appropriate for students of both genders, that is, the strategy is appropriate for mixed-gender classes. This suggestion is important because nowadays mixed-gender education is very common so the strategies being used and the teaching process in general, should suit both genders equally and also ensure knowledge acquisition and metacognition development.

The significance of this study is reflected in the fact that there are no other studies examining the implementation of this particular mKWL strategy with boys and girls separately, and there is also a lack of studies on the effects of any teaching strategy on both students' physics achievement and metacognitive awareness in mixed-gender lower secondary education. The study findings have implications for both educational and research practice. Implementing the proposed mKWL strategy in physics classes in mixed-gender lower secondary education can be suggested in order to improve physics achievement as well as metacognition of students of both genders. The implementation of the strategy in physics classes in other schools is planned and also its implementation in other subjects. Besides, it can be implied that the application of the mKWL strategy for teaching concepts regarding natural phenomena and processes can be extended to lower levels of education (primary education). Therefore, plans for the further application of the proposed strategy will be defined in the next period. To make this possible, training for the implementation of this strategy is needed for both teachers and students and also the provision of appropriate resources is necessary. Additionally, this research raises many opportunities for further studies. Future research can include broader physics content and also contents from other school subjects, as well as different age groups of students. Furthermore, it would be interesting to carry out research with design and procedure similar to those described within this research to examine the appropriateness of implementation of different teaching and learning strategies for boys and girls.

Declaration of Interest

Authors declare no competing interest.

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