European Journal of Educational Research

Volume 10, Issue 2, 785 - 798.

ISSN: 2165-8714
https://www.eu-jer.com/

Is Peer Instruction in Primary School Feasible? : The Case Study in Slovenia

Jerneja Pavlin*
University of Ljubljana, SLOVENIA

Tina Čampa
Primary school Brinje Grosuplje, SLOVENIA

Received: December 2, 2020 ▪ Revised: March 6, 2021 ▪ Accepted: March 20, 2021

Abstract: An evidence-based, interactive teaching method peer instruction (PI) is promoted to support effectiveness over more commonly used teaching methods. Usually it is proposed for the university and upper secondary school. The research reports on the implementation of the PI approach in teaching subject Science and Technology (S&T) in the 4th grade of primary school. The aim of this research was to verify the feasibility of this approach for much younger students in primary school by evaluating the students' progress in the subject S&T, identifying the differences in individual progress in relation to students' general learning success, and determining students' opinions about the approach and where no desired progress has been made. In a selected Slovenian primary school, a classroom with 26 students (age 9 – 10) was included in the study and 5 different content areas (Earth's motion, Matter, Magnetism, Forces and motion, and Electricity) were taught using this PI approach. Results show that students made progress in all content areas and no differences were identified in the progress of individual students in terms of general learning success. Students were satisfied with the approach, although more than half of them found the multiple-choice questions as too difficult. Although the PI approach is successful, teachers must be aware that some persistent and widespread misunderstandings may still remain and require additional intervention.

Keywords: *Misconceptions in physics and chemistry, peer instruction approach, primary education, science and technology subject.*

To cite this article: Pavlin, J., & Čampa, T. (2021). Is peer instruction in primary school feasible?: The case study in Slovenia. *European Journal of Educational Research*, *10*(2), 785-798. https://doi.org/10.12973/eu-jer.10.2.785

Introduction

Early science education lays the foundation for the later development of science concepts, practices and attitudes. Therefore, it is essential to gradually and systematically introduce scientific experiences, awareness, and vocabulary at an early stage in the education system. The preparation of lessons to achieve these goals is demanding, but there are strategies to enhance students' and teachers' scientific literacy (Dewi et al., 2020; Holbrook & Rannikmae, 2007; James, 2013; Jarvis et al., 2011; Smith et al., 2011).

The formation of awareness, attitudes toward and understandings about nature begins early in child's development, as children naturally ask questions and draw conclusions from experiences and progress with them (Dawes, 2015; Eshach & Fried, 2005). Effective science teaching enables students to change, reconstruct and generate science concepts (Krnel et al., 2005). Concepts are formed not only through concrete direct experience, but also through secondary language-based experiences, which students use for articulate, reflect upon and discuss ideas related to nature and doing (Dawes, 2015).

Moving science instruction from a teacher-directed approach toward a more student-engaged approach is bringing forward the development of student autonomy and responsibility for learning (Arthurs & Kreager, 2017; Kaya & Kablan, 2013; Prince, 2004). An example of a method is peer learning, which plays an increasingly important role in education, especially in primary education. Peer learning in general might be described as learning in smaller groups in which students (potentially) achieve the best learning outcome when they consider peers' ideas, develop them and at the same time help other students to achieve their best learning outcomes (Thurston et al., 2007).

One of techniques used in peer learning is the PI approach that enables applying concepts in a non-threatening environment and gives students rapid feedback on their work, usually used at university level (Correia & Harrison,

* **Corresponding author:**
Jerneja Pavlin, University of Ljubljana, Faculty of Education, Slovenia. ✉ jerneja.pavlin@pef.uni-lj.si

© 2021 The Author(s). **Open Access** - This article is under the CC BY license (https://creativecommons.org/licenses/by/4.0/).

2020; Lasry et al., 2008; Mazur, 1997; Vickery et al., 2015). An attempt was made to implement the PI in primary school. The paper presents the PI, alongside the evaluation of PI implementation in Grade 4 in chemistry and physics content areas within the subject of S&T in primary school.

Literature Review

The PI approach was developed in 1991 by Eric Mazur, a Harvard University professor of physics, with the aim of increasing learning outcomes in physics courses at university level (Lasry et al., 2008). The PI approach helps students to uncover inaccurate prior knowledge, find correct solutions and dispel common misconceptions, improve the articulation of opinions, accept the opinions of others, accept one's own mistakes, improve metacognitive skills, readiness to listen and discuss peer statements, and improve self-esteem (Crouch & Mazur, 2001; Gok, 2012–2015; Kim & Song, 2006).

Several authors identified teachers' positive views on the PI approach and demonstrated that after the discussion more secondary school and university students answered multiple choice questions correctly (Crouch et al., 2007; Lasry, 2008; Šestakova, 2013). For example, Crouch et al. (2007) report that 93% of teachers considered the PI approach to be a useful technique and that 70% of students gave positive feedback. Fagen et al. (2002) also report that teachers positively evaluated the technique. Crouch et al. (2007) and Pilzer (2001) find that 80% or more students chose the correct answer after the discussion. Suppapittayaporn et al. (2010) report on the average effectiveness of the PI approach with structured inquiry and on significantly better knowledge from comparing pre- and post-tests results with the results of the control group.

Moreover, Turpen and Finkelstein (2009) reported a variety of practices that are supported and modelled in the use of PI by faculties. Students were observed trying out, applying new physics concepts, and discussing physics with their peers in all the classrooms involved in the study. There were large differences in students' opportunities to take part in formulating and asking questions, evaluating the correctness and completeness of problem solutions, communicating scientific ideas in a public place, etc. However, Campbell and Schell (2012) and Šestakova (2013, 2016) presented their experiences with the PI approach in secondary schools. They discuss the adaptation of the PI approach for upper secondary school, especially concerning written learning materials for individual work before the questions and group work (or work in pairs), and the formulation of questions based on curriculum content. Campbell and Schell (2012) suggested assigning reading materials at homework to ensure that students have the prior science knowledge necessary for discussions because it is time consuming to read them in school. Experience shows that in a school lesson in duration of 45 minutes fewer than 6 ConcepTest questions are solved by students. However, ConcepTests are conceptual multiple-choice questions suitable for immediate quantitative assessment of student understanding. The arrangement of seats has to enable communication with all group members. Groups of students should be heterogeneous regarding learning abilities (Mazur, 1997). Šestakova (2016) reported that prior science knowledge is important. After a few uses of PI, some students became curious about what other students thought. Most students (94%) liked the lesson more or equally when PI was used, and it was observed that students deepened their science knowledge and understanding and developed communication skills as a result of the PI approach.

The PI approach was transferred from university physics courses to different fields (mathematics, physiology, science, social studies etc.) and different levels of education (Bulut, 2019; Giuliodori et al., 2006; Lasry et al., 2008; Olpak et al., 2017; Pilzer, 2001; Šestakova, 2016). It is evident that not only university students but also secondary school students progressed in their science knowledge and understanding of science concepts as a result of using the PI approach.

Moreover, the literature review shows that Mazur's active learning PI approach is most often applied at the university level, especially in physics lectures (Crouch & Mazur, 2001). However, the PI is also adapted for the secondary school level, more often for the upper secondary level (Campbell & Schell, 2012; Eryilmaz, 2004; Iverstine, 2010; Šestakova, 2016). There are some studies on groups from lower secondary level as well (from Grade 7 onwards) (Atasoy et al., 2014; Balta et al., 2017; Šeštakova, 2013). However, to the best of our knowledge, there are no reports on implementation PI in primary schools according to literature search.

Moreover, a review of the science education literature demonstrates that students have a limited understanding of science concepts, especially from physics and chemistry (e. g. density, electric circuit, Earth's motion, forces, heat, states of matter, etc.) and that there are many misconceptions among students from different educational, national and age levels. Researchers have identified that several misconceptions in physics and chemistry for primary and secondary school students are very difficult to change by commonly used teaching methods (Allen, 2010; Barrow, 2012; Buber & Coban Unal, 2017; Glauert, 2009; Grubelnik et al., 2018; Kind, 2004; Krnel, Watson & Glažar, 2005; Pine et al., 2001; Suppapittayaporn et al., 2010; Ugur et al., 2012).

Methodology

Research Goal

The aim of this study was to design PI lessons for primary schools on topics from the curriculum where several misconceptions occur, focusing on assessing the feasibility of the approach in primary schools and identifying which misconceptions still exist. As PI is relatively rarely used in primary schools, it would enable a deepening of science knowledge at primary school level, cover learning objectives from the curricula and allow students in a different way to learn from their peers and build science knowledge, communicate in the language of science and last but not least develop scientific literacy.

Therefore PI approach was implemented as approach in 5 different chemistry and physics curriculum content areas: Earth's motion, Matter, Magnetism, Forces and motion, and Electricity. The concrete research objectives were to evaluate the students' progress in science knowledge and understanding in the 4th grade as a result of the PI approach, to identify the students for whom the PI approach is most appropriate, gather student opinions about PI, and determine which misunderstandings of the students in the investigated class cannot be corrected by the PI approach for considered contents.

The research questions were following:

RQ1: What is students' overall progress in science knowledge after discussing in pairs compared to their science knowledge before the discussion in terms of number of correct answers?

RQ2: How much do individuals progress in terms of number of correct answers after discussing in pairs compared with their pre-discussion answers?

RQ3: Which students would, according to students' general learning success, benefit most from the PI approach?

RQ4: What is students' opinion about the use of the PI approach?

RQ5: What misunderstandings are identified in the 5 content areas studied (Earth's motion, Matter, Magnetism, Forces and motion, Electricity)?

Sample and Data Collection

The sampling method was non-randomized and purposive. The study included all students in an intact class, a total of 26 students from Grade 4 of a selected rural primary school, including 10 girls and 16 boys aged 9 and 10 years. Fourth-grade students were chosen due to their ability to read fluently and understand the content of the multiple-choice questions. Pairs were chosen instead of groups due to the arrangement of seats in the computer room and to allow for the active participation of all students. From the end of school year 3 and onwards, the teacher creates a final numerical grade for all subjects. Based on his or her average grades in each subject, the student's general learning success in the class is determined as follows: 'satisfactory' (2), 'good' (3), 'very good' (4) and 'excellent' (5) (Taštanoska, 2017). In terms of their general learning success, the students were a mixed group. Before the study, the parents were briefed about the research. Consent was obtained for the research participants (i.e., students) from their parents, as required by the ethics standards at the Faculty of Education, University of Ljubljana. To ensure anonymity, each student was assigned a code consisting of P and a number (e.g., P1).

All data were collected in Slovenian. The knowledge data were obtained using 5 learning content tests with multiple-choice questions, a questionnaire and field notes. The multiple-choice questions in the presented study are not called the ConcepTest questions because the multiple-choice questions sometimes tested science knowledge and not the understanding of the science concept. Content tests included 9 to 15 multiple-choice questions, each with 3 distracters and 1 correct answer.

Multiple-choice questions were designed in line with the learning objectives from the curricula of the S&T subject, minimal standards of knowledge and higher levels of understanding and were based on the research published in Trends in International Mathematics and Science Study (TIMSS, 2007, 2011), as well as on S&T textbooks. The number of questions for each content test differed according to the curricular learning objectives and the complexity of the learning content. This approach and careful review of the knowledge test questions by two science educators and two primary school teachers ensured content validity and reliability of the knowledge tests. Answers were collected by clickers and the program TurningPoint.

A paper-pencil questionnaire based on students' opinions of the approach was also used. It consisted of 6 questions covering the popularity and sensitivity of the PI approach, the advantages and disadvantages of the PI, the complexity of the posed questions, and the opinions about the answering systems, i.e., clickers. The instruments were prepared specifically for this research.

After careful consideration, the PI was implemented in a Grade 4 classroom. The primary school teacher, who was already a teacher at the selected school, was trained in PI by an expert in science education. According to the yearly teacher plan for the subject S&T, the selection of content areas throughout the school year was performed first. One hour for the introduction tutorials and 10 school hours (2 block school hours for the selected content area) were allotted for PI implementation in the classroom. Five content areas (Earth's motion, Matter, Magnetism, Forces and motion, Electricity) with a certain number of learning objectives from three curricular content blocks (Forces and motion, Matter and Phenomena) were chosen, and multiple-choice questions were prepared. The electricity and magnetism content areas are presented to the students in Grade 4 for the first time, whereas other contents are partially included in the curriculum for Environmental studies in previous years (Balon et al., 2011; Kolar et al., 2011).

Students were taught each selected content area for three school hours according to the curriculum for S&T, taking into account the textbook and the teacher's autonomy. In this way, students should have already acquired experiences and science knowledge and understanding of the content areas. Before the first implementation of the PI approach, one school hour was spent on presenting the PI approach to students by using a schematic presentation of the PI steps, as shown in Figure 1; presenting instructions for discussion; and presenting clickers and the TurningPoint program for collecting the answers in the computer classroom.

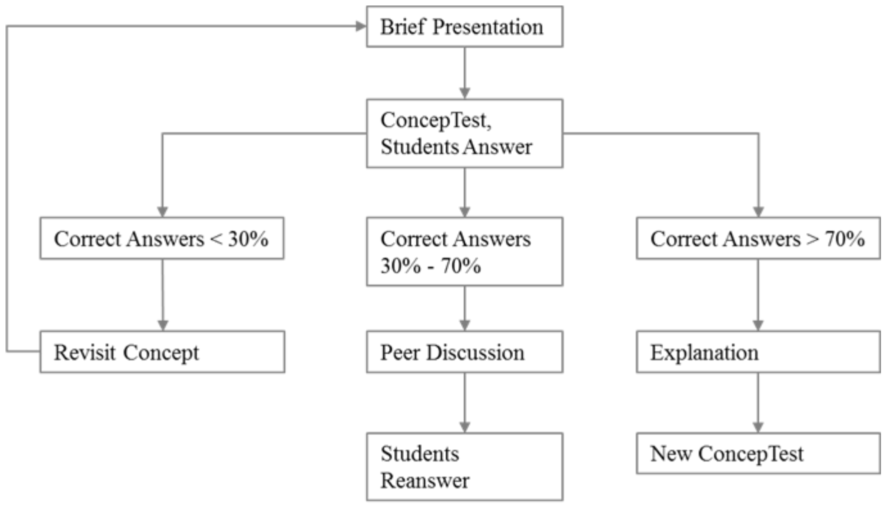


Figure 1. The structure of the PI approach (Lasry et al., 2008).

The teacher formed pairs by taking into account friendships and heterogeneity in prior science knowledge. The procedure of the PI approach was presented with a few examples of multiple-choice questions illustrating all the steps of the PI approach. The teacher presented examples of arguments to present students the idea of how to discuss and justify the selection of the answer. It was stressed that students could use everyday language and list arguments related to previous experiences, facts, observations, etc. The teacher translated the everyday wording to scientific language during the final explanation. The teacher confronted students with time limitations for the answering and the condition for the end of the discussion – quiet in the classroom. She also clearly presented her role (reading questions and leading the explanation). Students were encouraged to rely on their knowledge and understanding during the discussion, not on the opinion of the most convincing member of the pair, the person who has better grades in general, etc.

The school hours with the PI approach were carried within 5 months of school process. The teacher collected data on students' answers and field notes on the PI implementation.

Analyzing of Data

The data were collected using the TurningPoint program and the questionnaire, and were analysed using Excel. Because this research was done on a relatively small sample the basic statistics for the analysis of the results only (arithmetic mean (*M*) and standard deviation (*SD*)) of the numerical variables, average normalized gain ($<g>$) and fractional gain (g) was used. To find the effectiveness of the PI approach, an average normalized gain was calculated from the percentage of correct answers before and after the discussion, $<g>$ = (<correct answers after the discussion in %> - <correct answers before the discussion in %>) / (100% - <correct answers before the discussion in %>). Benchmarks to define low gain (0-0.3), medium gain (0.3-0.7) and high gain (0.7-1.0) are listed by Hake (1998). Because $<g>$ is a class average normalized gain, the fractional gain for an individual student was calculated similarly, taking into account all the answers from all content areas. In this case, g might be negative if a student answers more questions correctly before the discussion that after it. The suggested specific ranges for g are the same (Hake, 1998; Suppapittayaporn et al., 2010).

Progress might be achieved only for questions that were first answered incorrectly. The percentage of questions in which students progressed was calculated as a share of arithmetic mean of correct answers first answered incorrectly in % to arithmetic mean of in correct answer before the discussion in %. The percentage of questions in which students regressed was calculated as a share of arithmetic mean of incorrect answers first answered correctly in % to arithmetic mean of correct answers before the discussion in %.

The questionnaire contained six questions, four closed and two open, covering a research question on the students' opinion of the approach. Data were entered into Excel and responses to the open-ended questions were coded. Two researchers (i.e., the authors of this paper) independently read and coded the responses multiple times (Vogrinc, 2008). Cross-checking revealed the ideal level of agreement between the codes assigned by the two researchers.

Results

Table 1 presents the arithmetic mean of the percentage of correct answers and the standard deviation before the discussion and after the discussion for each learning content area. It is necessary to take into account that the number of multiple-choice questions for each content test for a specific content area varies. An average normalized gain is presented in Table 1 for each content set. The difference between the percentage of correct answers before and after the discussion is the highest in the forces and motion content area (medium gain, <*g*> = 0.55) and the lowest in magnetism (medium gain, <*g*> = 0.32). The percentage of students who had an ability to progress and progressed in number of correct answers varied between 44% and 63%, whereas up to 17% of students regressed.

Table 1. Arithmetic mean (M) and standard deviation (SD) for the percentage of correct answers before and after the discussion, the average normalized gain (<g>), and the percentage of questions in which students progressed and regressed

Content area	**Correct answers before the discussion**		**Correct answers after the discussion**		**<g>**	**Questions with students' progress [%]**	**Questions with students' regression [%]**
	***M* [%]**	***SD* [%]**	***M* [%]**	***SD* [%]**			
Earth's motion	51	19	75	28	0.49	58	9
Matter	35	12	64	13	0.45	44	4
Magnetism	53	17	68	36	0.32	56	8
Forces and motion	51	14	78	9	0.55	63	9
Electricity	55	13	72	31	0.38	55	17
Average	49	15	71	23	0.44	55	9

Table 2 shows the percentage of correct answers for all 5 content areas for individual students after the discussion and the fractional gain *g*, for which the average for all students in all content areas is 0.44. Most of the individual students progressed in science knowledge and understanding after the PI approach across 5 content areas identified by *g* (range from 0.20 [P15] to 0.71 [P17], average *g*: 0.44, high gain: 1 student, medium gain: 22 students, low gain: 3 students. P17 and P2 progressed the most (*g* ranges 0.71 and 0.65) but P17 did not have the highest number of correct answers in the group of fourth graders. The general learning success of P17 was 'very good' and that of P2 was 'very good', as they were paired with 'excellent' students. P17 actively participated only if the activity was intense or somehow invigorating, and it seems that the PI was that type. P2 was paired with communicative students who had highly developed argumentation skills that might have helped their constructive discussion and therefore retention. Students who answered most of the questions correctly before the discussion did not have the opportunity to progress. Therefore, their *g* is small. For example, P15 was an 'excellent' student who gave the highest amount of correct answers before the discussion (34 out of 44), but since he answered only 2 more questions correctly after the discussion, his *g* is the smallest.

Table 2. Percentage of correct answers before and after the discussion for all 5 content areas and fractional gains (g) per student

Student	**Correct answers [%]**		***g***	**Student**	**Correct answers [%]**		***g***	**Student**	**Correct answers [%]**		***g***
	Before	**After**			**Before**	**After**			**Before**	**After**	
P1	59	80	0.50	P10	68	84	0.50	P19	43	61	0.32
P2	41	80	0.65	P11	59	75	0.39	P20	48	61	0.26
P3	32	61	0.43	P12	41	75	0.58	P21	55	73	0.40
P4	45	61	0.29	P13	61	73	0.29	P22	52	73	0.43
P5	25	59	0.45	P14	57	73	0.37	P23	66	82	0.47
P6	34	59	0.38	P15	77	82	0.20	P24	52	82	0.62
P7	55	73	0.40	P16	59	82	0.56	P25	43	64	0.36
P8	55	73	0.40	P17	45	84	0.71	P26	48	64	0.30
P9	66	84	0.53	P18	59	84	0.61	Average	52	73	0.44

Students with ‘good’ general learning success progressed in 13.25 questions (out of a total of 44 included in the discussions) on average (Table 3). Furthermore, students with ‘good’ general learning success progressed the most, while those with ‘satisfactory’ general learning success made the least progress.

Table 3. General learning success of the student sample and the arithmetic mean of the number of questions (M) in which students progressed, with added standard deviation (SD).

General learning success	Number of students	*M*	*SD*
‘Satisfactory’	1	8.00	/
‘Good’	4	13.25	3.30
‘Very good’	13	12.15	4.16
‘Excellent’	8	10.13	2.36
All students	26	11.54	3.60

The results of a questionnaire showed that most students (85%) liked the PI approach to deepen their knowledge and understanding of science content and believed that it led them to greater content acquisition. More than half of the students (65%) assessed the questions as too demanding in general. Eighty-five per cent of the students agreed with the statement that the discussions in pairs helped them in learning the content. In the PI approach, 38% of students liked working with clickers, and 38% liked working in pairs. Some mentioned their interest in learning the content questions, the anonymity of the results, the presentation of the results on the screen, some learning content-specific questions, the fact that they did not need to write in notebooks, etc. The majority of students (92%) would not change anything when using the PI approach, and 8% of students suggested using shorter questions.

Table 4 presents examples of multiple-choice questions according to the learning objective from the curriculum. Tables 5–9 present the percentage of students who correctly answered various multiple-choice questions before and after the discussion.

Table 4. Examples of multiple-choice questions according to the learning objectives from the S&T curriculum and their level according to Bloom’s taxonomy. The percentage of students who already knew the answer and who progressed was added. In the first two examples, all the answers given by the students were correct after the discussion

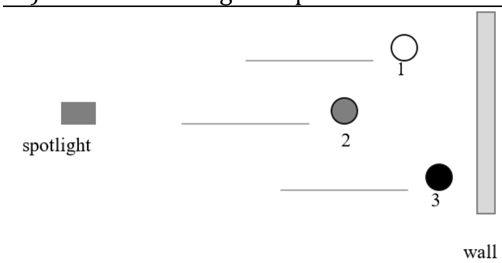
Question	Learning objective from the curriculum	Level (Bloom's taxonomy)	Students [%] Already knew	Students [%] Progressed
Why is it dark at night? A) Because there is no sun. B) Because the light does not fall on that part of the Earth. C) Because we go to sleep. D) Because the sun does not shine at night.	Students explain why day and night vary according to the brightness.	Comprehension	69	100
Magnet has two poles. What are they called? A) Upper and lower pole B) North and South pole C) East and West pole D) Positive and negative pole	Students know that a magnet has a north pole and a south pole.	Knowledge	69	100
 Mark is taller than Anna, and Nick is shorter than Anna. Each of them is marked with the number on the sketch. They are placed between the spotlight and the wall in a way that their shadows on the wall are equally tall. Which statement is correct? A) Mark is marked with number 1. B) Mark is marked with number 2. C) Mark is marked with number 3. D) The circles on the sketch are shown incorrectly, as everyone should be equally far from the wall.	Students interpret the interdependence of the position of the light and the illuminated object in relation to the size and position of the shadow.	Analysis	38	56

Table 4. Continued

Question	Learning objective from the curriculum	Level (Bloom's taxonomy)	Students [%]	
			Already knew	Progressed
The grandfather pulls the sleigh on which Bob sits. Which force decelerate the movement of the sleigh on a frozen surface? A) Bob's force. B) Friction force. C) Gravity force. D) Grandfather's hand force.	Students summarize the friction force in practical case.	Comprehension	31	44

From Table 5 it is evident that students discussed 8 out of 10 multiple-choice questions in the content area Earth's motion. After the discussion, students' knowledge and understanding increased in 7 items.

Table 5. The percentage of students who answered correctly on questions from the content area Earth's motion before and after the discussion.

Question	Learning goal from the curriculum in Earth's motion	Correct answers before the discussion [%]	Correct answers after the discussion [%]
1.	Connect the formation of day and night with the rotation	69	85
2.	of the Earth.	100	/
3.	Explain why day and night differ in brightness.	69	100
4.	List some natural and artificial lights.	58	100
5.	Explain the interdependence of the position of the light	92	/
6.	and the illuminated object in relation to the size and	62	92
7.	position of the shadow.	62	92
8.	Recognizes the Moon's eclipse on a sketch.	31	23
9.	Explain the formation of the Moon's phases.	23	46
10.	Know that objects are seen because light reflects.	62	92

Table 6 shows that students discussed 9 out of 10 multiple-choice questions in the content area Matter. After the discussion, the percentage of students who answered correctly was higher in all 9 items. Difficulties were identified in identifying the separation steps of the mixture of three components and their influence on the change in the properties of the substances. Although, students have difficulties in linking school science to everyday life, in details, identifying the hardness of rocks that travels longest from their shape and connecting clearing of dust water due to the density of the substances in the mixture, as 54 % of the students answered these questions correctly after the discussion.

Table 6. The percentage of students who answered correctly on questions from the content area Matter before and after the discussion.

Question	Learning goal from the curriculum in Matter	Correct answers before the discussion [%]	Correct answers after the discussion [%]
1. 2.	Know the procedures for mixture separation.	50 35	85 46
3. 7.	Prove that the heating and cooling of the substance cause changes in the properties of the substance.	92 62	/ 85
4. 5. 6. 9.	Classify substances according to their properties (kneading, compressibility, hardness, and density).	35 65 46 35	62 92 54 54
8.	Identify the essential properties of permeable and non-permeable substances for water and air. Explain the correlation of the properties of a substance with their use.	46	69
10.	Identify the essential properties of permeable and non-permeable substances for water and air.	35	62

Students discussed 8 out of 10 multiple-choice questions in the content area Magnetism (Table 7). The percentage of students who answered correctly after the discussion increased in 7 items. However, 31 % of students still think that magnets attract gold objects (2nd question). Despite the learning how the compass works, 38 % of the students have difficulty in recognizing what happens when the compass is next to the magnet (6th question). Question 10 was the most complex as it involved the figure of 4 car toys with magnets and asked what happens if the first car breaks. However, it was found that question 10 is complex for students in Grade 4, despite the understanding, it also emphasizes the reading abilities of students.

Table 7. The percentage of students who answered correctly on questions from the content area Magnetism before and after the discussion.

Question	Learning goal from the curriculum in Magnetism	Correct answers before the discussion [%]	Correct answers after the discussion [%]
1.	Show that there are attractive forces between a magnet and iron.	92	/
2.		50	69
7.		46	69
3.	Know that a magnet has a north pole and a south pole.	69	100
8.		69	92
4.	Show that there are attractive and repelling forces between magnets.	65	92
5.		69	100
6.		42	62
9.	Explain the importance of the practical use of magnets.	88	/
10.	Show that there are attractive and repelling forces between magnets. Explain the importance of the practical use of magnets.	31	23

From Table 8 it is evident that students discussed about 8 out of 10 multiple-choice questions on Forces and motion. After discussion, students' knowledge and understanding increased in all items discussed. The discussions were rich in this content area and students asked several constructive questions to the teacher. This could confirm students' rich experience with the content.

Table 8. The percentage of students who answered correctly on questions from the content area Forces and motion before and after the discussion.

Question	Learning goal from the curriculum in Forces and motion	Correct answers before the discussion [%]	Correct answers after the discussion [%]
1.	Show that bodies move down due to the force of gravity.	54	84
3.		69	85
4.		92	/
5.		88	/
2.	Know that bodies move when force is applied.	69	92
6.	Prove friction force in practical cases.	38	69
8.		38	69
7.	Identify the different ways that bodies move.	46	77
9.	Explain the importance of the properties of surfaces with respect to different modes of movement.	42	69

Table 9 shows that students discussed 12 out of 15 multiple-choice questions in the content Electricity. After discussion students' knowledge and understanding increased for 8 items discussed. During the PI implementation of electricity, students did not feel comfortable; therefore, discussions were short. 3 questions did not take part in discussion because 70% or more correct answers before discussion. For 2 items, the percentage of questions after discussion was lower than before the discussion. The results showed that students were not familiar with different power plants (question 5) and the problem with interpretation of question 15 came to the fore.

Table 9. The percentage of students who answered correctly on questions from the content area Electricity before and after the discussion.

Question	Learning goal from the curriculum in Electricity	Correct answers before the discussion [%]	Correct answers after the discussion [%]
1.	Know different types of power plants.	38	69
2.	List the sources and consumers of electric current.	46	62
3.		38	38
4.	Describe the path of electricity from the power plant to the consumer.	81	/
5.	Know different types of power plants.	46	38
6.	Know the elements of the electric circuit and their roles.	69	100
7.		65	100
8.		81	/
10.		54	15
11.		62	100
12.		42	46
9.	Understand the importance of electric conductors and insulators.	69	92
13.		77	/
14.	Know the dangers of electric currents.	65	100
15.	Identify the benefits of saving energy.	8	0

Discussion

The research results demonstrate the feasibility of the PI approach for primary school students by assessing students' progress in the subject S&T, identifying the differences in individual progress in relation to students' general learning success, and identifying students' opinions about the approach and remaining misconceptions. The answers are formed with regard to the research questions.

The first research question relates to the differences between students' overall progress in terms of the correct answers given by students by content area. The PI implementation was effective because the <*g*> was medium for all 5 content areas (ranging from 0.32 [Magnetism] to 0.55 [Forces and motion] (Table 1). However, lower normalized gains for the content areas Magnetism and Electricity may due to students' lack of experience with the content. Overall, according to PI, students made progress in their science knowledge and understanding in the various content areas: from 49% correctly answered questions prior to the discussion to 71% after the discussion. The percentage of students who made progress varied between 44% and 63%, while the overall, 9% declined (ranging from 4% [Matter] to 17% [Electricity]). This result is comparable to the results of the study conducted among physics students at Harvard University, which found that about 6% of students regressed, while the percentage of correct answers was approximately 80% (Crouch et al., 2007). It is shown that active participation and immediate feedback result in students' science knowledge and understanding being internalized, reflected or revised in discussions, without the pressure to use only scientific language (Correia & Harrison, 2020; Dawes, 2015, Hattie & Timperley, 2007; Ketonen et al., 2020).

The second research question deals with the differences that relate to the progress of individuals in terms of the number of correct answers after discussion in pairs compared to their answers before the discussion (Table 2). It might be speculated that the PI brings science knowledge and understanding benefits to students with average ('good' and 'very good') general learning success (of course, when paired with students with greater science knowledge and understanding). The obtained results are comparable to those of a study on the PI approach conducted in Thailand for forces and motion learning content, where <*g*> was 0.45 (Suppapittayaporn et al., 2010). The finding supports heterogeneous grouping regarding reading abilities, prior science knowledge and argumentation skills.

The third research question deals with the benefit of students from the PI approach with different learning success (Table 3). This finding could lead to the conclusion that the PI approach is most suitable for students with 'good' general learning success and that the formation of heterogeneous pairs or groups is necessary. However, one must consider how group discussions in pairs assist in solving qualitative problems in physics (Tao, 1999).

The fourth research question relates to identification of students' opinion about the use of the PI approach. Overall, students were satisfied with the PI approach. They noted that the PI approach helped them to better assimilate the learning content, which might be a consequence of active participation, being allowed to make and correct mistakes, and hidden coercion as a result of thinking aloud and discussing the learning content (Dawes, 2015; Šestakova, 2016). Working in pairs, clickers, anonymity and interesting content areas were positively highlighted. Similarly to our study at the primary school level, working with clickers was revealed as an advantage (because it was not necessary to sit, listen and write) of the PI in surveys conducted in 2016 by Šestakova and in 2007 by Crouch et al. at the secondary and university levels. The presented results of the PI approach reflect the effect of the teacher less thoroughly because the teacher taught S&T to the students in the study sample for the whole school year. However, this situation is rarely achieved in the Slovenian school system because new teaching techniques are implemented only by the most enthusiastic teachers. The following remark must be added as an incentive to any teacher deterred by new techniques. When the students evaluated the S&T subject at the end of the school year, they all highlighted the PI approach as a positive aspect. They explained that, in addition to learning the new science learning content, they learned to accept the opinions of their peers and to work together to find correct answers to questions.

The fifth research question deals with the identification of misunderstandings in solving multiple-choice questions on 5 content areas (Earth's motion, Matter, Magnetism, Forces and motion, Electricity). However, Moon phases and Moon's eclipse are identified as difficult contents, as less than 50 % of the students answered correctly after the discussion. Trundle et al. (2007), however, summarize research by many authors on basic astronomical concepts and show that the content on Moon phases is too complex to be introduced to the lower grades of primary school, as students are developmentally unable to assimilate complex phenomena. In a sense, the present results confirm the above and underline the role of the qualified teacher to present the content with embodiment (Geršak et al., 2020; Susman & Pavlin, 2020). It is a similar situation to the 9th graders, e.g. Tüysüz (2009) reports that 71% of the students had problems in choosing the order of separation techniques for mixtures with three or more components. Content Matter is included in the curriculum from Grade 1 of primary school onwards (Balon et al., 2011), However, this reflects the importance of previous experimental experience comes to the fore (Kiray & Simsek, 2020; Logar et al., 2017). The common misconception is that all metals are attracted by a magnet (American Institute of Physics, 1998; Hickey & Schibeci, 1999). Here, the importance of the development and use of language (specialized vocabulary) and reading abilities come to the fore, as these are very important for being able to communicate in the field, to read fluently and to understand science texts (Mullis et al., 2013). Forces and motion were a familiar area of content for students, while the correct formulation of arguments can be difficult even for excellent students (Gok, 2011; Liu & Fang 2016). Some sub-contents of the examined contents are after the PI still identified as those where the prior knowledge is negligible, which is why it is difficult to discuss them. This is shown by the small percentage of students who show progress or even regression in their answers. The difficult sub-contents identified are Moon phases, separation of mixtures, magnetic properties of metals and electricity per se. These sub-contents are also identified as challenging also by other researchers (American Institute of Physics, 1998; Liu & Fang, 2016; Trundle et al., 2007). It is therefore necessary to consider how they can be presented to students in a more holistic and understandable way from the very beginning.

Conclusion

The aim of the present study was to determine whether the PI approach is feasible in primary-school science education. The study was conducted with a group of 4th grade students in selected content areas in physics and chemistry. The PI was adapted in a way that students worked in pairs in the computer room after the regular presentation of the contents in the classroom. It was ascertained that the number of correct answers given after pair discussion was greater than the number of correct answers given before the discussion. The results of the study show that the PI approach results in primary school students' science knowledge and understanding progression in all selected content areas and that general learning success does not affect the individuals' progress. For the selected sample, however, it was ascertained that students who progressed the most had 'good' general learning success. The students were satisfied with the PI approach even though more than half of the students evaluated the questions as being too difficult. They expressed that they acquired the learning contents better with the PI approach. They liked working in pairs and using the clickers for providing immediate feedback. However, some sub-contents are due to the lack of prior knowledge, experience and/or complexity still identified as those where teacher should use different teaching methods and approaches. The results show that it is possible to implement the PI approach in the primary school classroom, where it is shown to be appropriate not only for secondary and university students, but also for students in primary schools. Furthermore, the results of our research and TIMSS might predict similar results of the PI approach with fourth graders in other cultural contexts.

Recommendations

Implications for the educational process

The duration of the lesson using the PI approach should be limited to one school hour (45 minutes), as the students were already quite tired after the discussion, which lasted two school hours (90 minutes). Pairs/groups of students should be formed after the pre-test covering the material to be discussed and then, based on the results, divided into mixed groups according to academic achievements. Students should have prior knowledge that can be acquired in regular classes in primary school. Multiple-choice questions in PI lessons should carefully address misconceptions and follow Bloom's taxonomy from easiest to most difficult. However, to cover individual topics, it is important for the teacher to have a good professional content knowledge to identify misconceptions about the topic and prepare materials for the pedagogical process.

Further research guidelines

The study has raised several issues for follow-up studies on the PI approach in primary schools. First, it would be interesting to compare science knowledge and understanding gained in one subject between the control and experimental groups. Moreover, further research is also necessary to properly understand the impact of active learning through the PI approach on the retention of science knowledge, the motivation for science education, achievement in tests with science learning content, the long-term understanding of science concepts, reading abilities, and the contribution to a positive classroom climate in primary schools.

Limitations

Nevertheless, the present study on PI approach implementation has several limitations. The number of multiple-choice questions in the content tests was not equal for all content areas, and the number of diverse questions according to the taxonomy was not the same. Some possible answers were not of equal length, and some wrong answers were not convincing enough. Multiple-choice questions that caused difficulties for excellent students were also identified. The duration of two school hours of work with the PI approach in each content area was too long for the 4th graders. Working in groups of 3 or 4 students instead of pairs allows for more interactions. The formation of pairs might have also influenced the result. The sample was small. The result cannot be generalized to the basic set.

Acknowledgements

Authors are grateful to Mojca Čepič and Saša Ziherl for useful discussions and for their comments during the preparation of the paper.

References

Allen, M. (2010). *Misconceptions in primary science.* Open University Press.

American Institute of Physics. (1998). *Children's misconceptions about science*. Brookhaven National Laboratory. https://www.bnl.gov/education/static/pdf/Childrens_Misconceptions_about_Science.pdf

Arthurs, L. A., & Kreager, B. Z. (2017). An integrative review of in-class activities that enable active learning in college science classroom settings. *International Journal of Science Education, 39*(15), 2073–2091. https://doi.org/10.1080/09500693.2017.1363925

Atasoy, S., Ergin, S. & Sen, A. I. (2014). The effects of peer instruction method on attitudes of 9th grade students toward physics course. *Eurasian Journal of Physics and Chemistry Education, 6*(1), 88–98.

Balon, A., Gostinčar Blagotinšek, A., Papotnik, A., Skribe Dimec, D., & Vodopivec, I. (2011). *Učni načrt, program osnovna šola, naravoslovje in tehnika* [Curriculum, program of primary school, science and technology]. National Education Institute Slovenia.

Balta, N., Michinov, N., Balyimez, S., & Ayaz, M. F. (2017). A meta-analysis of the effect of peer instruction on learning gain: Identification of informational and cultural moderators. *International Journal of Educational Research, 86*, 66–77. https://doi.org/10.1016/j.ijer.2017.08.009

Barrow, L. H. (2012). Helping students construct understanding about shadows. *Journal of Education and Learning*, *1*(2), 188–191. https://doi.org/10.5539/jel.v1n2p188

Buber, A., & Coban Unal, G. (2017). The effects of learning activities based on argumentation on conceptual understanding of 7th graders about "force and motion" unit and establishing thinking friendly classroom environment. *European Journal of Educational Research*, *6*(3), 367–384. https://doi.org/10.12973/eu-jer.6.3.367

Bulut, B. (2019). The impact of peer instruction on academic achievements and creative thinking skills of college students. *International Journal of Educational Methodology, 5*(3), 503–512. https://doi.org/10.12973/ijem.5.3.503

Campbell, R., & Schell, J. (2012, June 19). *Does peer instruction work in high schools? Turn to your neighbor.* The Official Peer Instruction Blog. https://blog.peerinstruction.net/2012/06/19/does-peer-instruction-work-in-high-schools-2/

Correia, C. F., & Harrison, C. (2020). Teachers' beliefs about inquiry-based learning and its impact on formative assessment practice. *Research in Science and Technological Education, 38*(3), 355–376. https://doi.org/10.1080/02635143.2019.1634040

Crouch, C. H., Watkins, J., Fager, A. P., & Mazur, E. (2007). *Peer instruction: Engaging students one-on-one, all at once*. Harvard University.

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977. https://doi.org/10.1119/1.1374249

Dawes, L. (2015). Discussion and science learning. In R. Gunstone (Ed.) *Encyclopedia of Science Education* (pp. 339–346). Springer.

Dewi, M. S., Setyosari, P., Kuswandi, D., & Ulfa, S. (2020). Analysis of kindergarten teachers on pedagogical content knowledge. *European Journal of Educational Research*, *9*(4), 1701–1721. https://doi.org/10.12973/eu-jer.9.4.1701

Eryilmaz, H. (2004). *The effect of peer instruction on high school students' achievement and attitudes towards physics.* Doctoral Thesis. The Middle East Technical University. https://etd.lib.metu.edu.tr/upload/12604702/index.pdf

Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology, 14*(3), 315–336. https://doi.org/10.1007/1-4020-4674-x_1

Fagen, A. P., Crouch, C., & Mazur, E. (2002). Peer instruction: Results from a range of classrooms. *The Physics Teacher 40*(4), 206–209. https://doi.org/10.1119/1.1474140

Geršak, V., Smrtnik Vitulić, H., Prosen, S., Starc, G., Humar, I., & Geršak, G. (2020). Use of wearable devices to study activity of children in classroom: Case study - learning geometry using movement. *Computer Communications*, *150*, 581–588. https://doi.org/10.1016/j.comcom.2019.12.019

Giuliodori, M. J., Lujan, H. L., & DiCarlo, S. E. (2006). Peer instruction enhanced student performance on qualitative problem-solving questions. *Advanced Physiology Education, 30*(4), 168–173. https://doi.org/10.1152/advan.00013.2006

Glauert, E. B. (2009). How young children understand electric circuits: Prediction, explanation and exploration. *International Journal of Science Education, 31*(8), 1025–1047. https://doi.org/10.1080/09500690802101950

Gok, T. (2011). The Impact of peer instruction on college students' beliefs about physics and conceptual understanding of electricity and magnetism. *International Journal of Science and Mathematics Education*, *10*(2), 417–436. https://doi.org/10.1007/s10763-011-9316-x

Gok, T. (2012). The effects of peer instruction on students' conceptual learning and motivation. *Asia-Pacific Forum of Science Learning and Teaching, 13*(1), 1–17.

Gok, T. (2013). A comparison of students' performance, skill and confidence with peer instruction and formal education. *Journal of Baltic Science Education 12*(6), 747–758.

Gok, T. (2014). Peer instruction in the physics classroom: Effects on gender difference performance, conceptual learning, and problem solving. *Journal of Baltic Science Education 13*(6), 776–788.

Gok, T. (2015). An Investigation of Student's Performance after Peer Instruction with Stepwise Problem-Solving Strategies. *International Journal of Science and Mathematics Education, 13*(3), 561–582. https://doi.org/10.1007/s10763-014-9546-9

Grubelnik, V., Marhl, M., & Repnik, R. (2018). Determination of the size and depth of craters on the Moon. *Center for Educational Policy Studies Journal*, *8*(1), 35–53. https://doi.org/10.26529/cepsj.322

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/doi:10.1119/1.18809

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

Hickey, R., & Schibeci, R. A. (1999). The attraction of magnetism. *Physics Education*, *34*(6), 383–388. https://doi.org/10.1088/0031-9120/34/6/408

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education, 29*(11), 1347–1362. https://doi.org/10.1080/09500690601007549

Iverstine, W. (2010). *Application of peer instruction in the high school setting* [Master's thesis, Louisiana State University and Agricultural and Mechanical College]. Louisiana State University Archive. https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=2309&context=gradschool_theses

James, J. (2013). Have words, will understand? *Primary Science, 127*, 10–13.

Jarvis, T., Pell, A., & Hingley, P. (2011). Variations in primary teachers' responses and development during three major science in- service programmes. *Center for Educational Policy Studies Journal*, *1*(1), 67–92.

Kaya, S., & Kablan, Z. (2013). Assessing the relationship between learning strategies and science achievements at the primary school level. *Journal of Baltic Science Education, 12*(4), 525–534.

Ketonen, L., Hähkiöniemi, M., Nieminen, P., & Viiri, J. (2020). Pathways through peer assessment: Implementing peer assessment in a lower secondary physics classroom. *International Journal of Science and Mathematics Education*, *18*(8), 1465–1484. https://doi.org/10.1007/s10763-019-10030-3

Kim, H., & Song, J. (2006). The features in peer argumentation in middle school students' scientific inquiry. *Research in Science Education, 36*(3), 211–233. https://doi.org/10.1007/s11165-005-9005-2

Kind, V. (2004). *Beyond appearances: students' misconceptions about basic chemical ideas* (2nd ed.). Durham University, School of Education. https://edu.rsc.org/download?ac=15564

Kiray, S. A., & Simsek, S. (2020). Determination and evaluation of the science teacher candidates' misconceptions about density by using four-tier diagnostic test. *International Journal of Science and Mathematics Education.* https://doi.org/10.1007/s10763-020-10087-5

Kolar, M., Krnel, D., & Velkavrh, A. (2011). *Učni načrt, program osnovna šola, spoznavanje okolja* [Curriculum, program of primary school, environmental studies]. National Education Institute Slovenia.

Krnel, D., Watson, R., & Glažar. (2005). The development of the concept of "matter": A cross-age study of how children describe materials. *International Journal of Science Education 27*(3), 367–383. https://doi.org/10.1080/09500690412331314441

Lasry, N. (2008). Clickers or flashcards: Is there really a difference? *The Physics Teacher, 46*(4), 242–244. https://doi.org/10.1119/1.2895678

Lasry, N., Mazur, E., & Watkins, J. (2008). Peer instruction: From Harvard to the two-year old college. *American Journal of Physics, 76*(11), 1066–1069. https://doi.org/10.1119/1.2978182

Liu, G., & Fang, N. (2016). Student misconceptions about force and acceleration in physics and engineering mechanics education. *International Journal of Engineering Education, 32*(1), 19–29.

Logar, A., Peklaj, C., & Ferk Savec, V. (2017). Effectiveness of student learning during experimental work in primary school. *Acta Chimica Slovenica, 64*(3), 661–671. https://doi.org/10.17344/acsi.2017.3544

Lucas, A. (2009). Using peer instruction and i-clickers to enhance student participation in calculus. *Primus, 19*(3), 219–231. https://doi.org/10.1080/10511970701643970

Mazur, E. (1997). *Peer instruction: A user's manual.* Prentice Hall.

Mullis, I. V. S., Martin, M. O., & Foy, P. (2013). The Impact of Reading Ability on TIMSS Mathematics and Science Achievement at the Fourth Grade: An Analysis by Item Reading Demands. In M. O. Martin & I. V. S. Mullis (Eds.), *TIMSS and PIRLS 2011: Relationships among Reading, Mathematics, and Science Achievement at the Fourth Grade – Implications for Early Learning* (pp. 67–110). TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College and International Association for the Evaluation of Educational Achievement .

Olpak, Y. Z., Karaoglan Yilmaz, F. G., & Yilmaz, R. (2017). Development of a student evaluation form toward peer instruction. *Turkish Online Journal of Educational Technology*, (Special Issue for INTE 2017), 839–845.

Pilzer, S. (2001). Peer instruction in physics and mathematics. *Primus, 11*(2), 185–192. https://doi.org/10.1080/10511970108965987

Pine, K., Messer, D., & St. John, K. (2001). Children's misconceptions in primary science: A survey of teachers' views. *Research in Science and Technological Education 19*(1), 79–96. https://doi.org/10.1080/02635140120046240

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231.

Smith, K. V., Loughran, J., Berry, A., & Dimitrakopoulos, C. (2012). Developing scientific literacy in a primary school. *International Journal of Science Education, 34*(1), 127–152. https://doi.org/10.1080/09500693.2011.565088

Suppapittayaporn, D., Emarat, N., & Arayathanitkul, K. (2010). The effectiveness of peer instruction and structured inquiry on conceptual understanding of force and motion: A case study from Thailand. *Research in Science and Technological Education, 28*(1), 63–79. https://doi.org/10.1080/02635140903513573

Susman, K., & Pavlin, J. (2020). Improvements in teachers' knowledge and understanding of basic astronomy concepts through didactic games. *Journal of Baltic Science Education, 19*(6), 1020–1033. https://doi.org/10.33225/jbse/20.19.1020

Šestakova, J. (2013). Peer Instruction for the Age Group 12–15. ICPE-EPEC 2013 Proceedings Prague: Faculty of Mathematics and Physics, Charles University. https://lup.lub.lu.se/search/ws/files/5487483/5049463.pdf

Šestakova, J. (2016). Case study of using peer instruction at upper secondary school. *Scientia in Educatione, 7*(2), 111–127. https://doi.org/10.14712/18047106.298

Tao, P. K. (1999). Peer collaboration in solving qualitative physics problems: The role of collaborative talk. *Research in Science Education, 29*(3), 365–383. https://doi.org/10.1007/bf02461599

Taštanoska, T. (2017). *The Education System in the Republic of Slovenia 2016*. Tiskarna Radovljica. https://eng.cmepius.si/wp-content/uploads/2015/08/The-Education-System-in-the-Republic-of-Slovenia-2016-17.pdf

Trends in International Mathematics and Science Study. (2007). *Matematične in naravoslovne naloge za nižje razrede osnovne šole* [Mathematics and Science Tasks for Primary Schools]. The Educational Research Institute.

Trends in International Mathematics and Science Study. (2011). *Naravoslovne naloge raziskav TIMSS* [Science Tasks from TIMSS Research]. The Educational Research Institute.

Thurston, A., Van de Keere, K., Topping, K. J., Kosack, W., Gatt, S., Marchal, J., Mestdagh, N., Schmeinck, D., Sidor, W., & Donnert, K. (2007). Peer learning in primary school science: Theoretical perspectives and implications for classroom practice. *Electronic Journal of Research in Educational Psychology, 5*(13), 477–496. https://doi.org/10.25115/EJREP.V5I13.1242

Trundle, K. C., Atwood, R. K., & Christopher, J. (2007). Fourth-grade elementary students' conceptions of standards-based lunar concepts. *International Journal of Science Education, 29*(5), 595–616. https://doi.org/10.1080/09500690600779932

Turpen, C., & Finkelstein, N. D. (2009). Not all interactive engagement is the same: Variations in physics professors' implementation of peer instruction. *Physical Review Special Topics – Physics Education Research, 5*(2) 1–18. https://doi.org/10.1103/physrevstper.5.020101

Tüysüz, C. (2009). Development of two-tier diagnostic instrument and assess students' understanding in chemistry. *Scientific Research and Essay*, *4*(6), 626–631.

Ugur, G., Dilber, R., Senpolat, Y., & Duzgun, B. (2012). The effects of analogy on students' understanding of direct current circuits and attitudes towards physics lessons. *European Journal of Educational Research*, *1*(3), 211–223

Vickery, T., Rosploch, K., Rahmanian, R., Pilarz, M., & Stains, M. (2015). Research-based implementation of peer instruction: A literature review. *Life Science Education, 14*(1), 1-11. https://doi.org/10.1187/cbe.14-11-0198

Vogrinc, J. (2008). *Kvalitativno raziskovanje na pedagoškem področju* [Qualitative research in the field of education]. Faculty of Education.