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DETERMINATION OF EDUCATIONAL EFFICIENCY AND STUDENTS' INVOLVEMENT IN THE FLIPPED BIOLOGY CLASSROOM IN PRIMARY SCHOOL

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Abstract. *The Flipped Classroom (FC) is a teaching approach in which students gain the first-exposure learning with online materials outside the classroom, and then, in the classroom, they focus on interactive or engaging exercises. Despite its considerable publicity, the studies focused on the FC in primary education are deficient. The aim of this research is to determine efficiency and students' involvement in the flipped Biology classroom in primary school, compared to the conventional classroom (CC) approach. Educational efficiency and students' involvement are measured by combining the values of the students' performance and mental effort on the test. Each task in the test was followed by the 5-point Likert scale for evaluation of invested mental effort. The total sample of this research included 112 students, aged from 12 to 13. The results show that the FC approach contributes to the reduction of the students' mental effort and an increase in the students' performance. On the basis of calculated efficiency and students' involvement of applied teaching approaches, it was concluded that the FC represents a feasible and efficient approach to Biology primary education.*

Keywords: *biology education, flipped classroom, educational efficiency, students' involvement, mental effort, primary school.*

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Introduction

Over the last decade, the use of information and communication technologies (ICT) has been rapidly spread across all segments of education, becoming a priority for all educational institutions. The integration of ICT into the teaching and learning process is a challenge for both teachers and students at all levels of education. Under the influence of ICT, new learning models are being developed in order to improve the quality of teaching approach and learning outcomes (Županec, Miljanović, & Pribićević, 2013). The increasing popularity of ICT, the time which students spend in front of the computer, and the ease of accepting technological innovations in students, impose a need for technology integration in a meaningful way in different subject areas already across the primary school curriculum (Costa et al., 2013). Developing the skill of using the ICT in primary school, students provide more complete intellectual activity in learning, through more independent search of the contents, their basic understanding and active, creative application.

With the purpose of providing a better learning environment that encourages student-centric activities, the recent innovation known as a flipped classroom (FC) has proved to become increasingly popular in recent years (Adams, Garcia, & Traustadóttir, 2016; Bergmann & Sams, 2012; Betihavas, Bridgman, Kornhaber, & Cross, 2016; Jensen, Kummer, & Godoy, 2015; McEvoy et al., 2016; Zhang, Dang, & Amer, 2016). The FC is active learning strategies in which the traditional lecture and homework are replaced by pre-class activities, typically viewing short videos, and the class time is devoted to interactive activities, problem-resolutions and discussions (Pienta, 2016). The FC can better assist a personalized learning, improve students' critical thinking ability, encourage collaborative learning, and accommodate students' different learning styles (Janz, Graetz, & Kjorlien, 2012; Rutherfoord & Rutherfoord, 2013; Szafir & Mutlu, 2013).

Research studies on testing the application effects of the FC approach in the implementation of Biology contents are insufficient, and they relate to higher education. In addition, the studies focusing on primary or lower-secondary education are deficient (Hultén & Larsson, 2016). On the other hand, in the Republic of Serbia there is an increasing number of primary school Biology teachers who accept the FC approach in their work with enthusiasm. They create short video clips to analyse the teaching material in Biology in primary school, and make the clips available on YouTube channels, thus providing the other teachers with materials in order to apply this learning model in their classrooms. Although there is a growing number of video clips in Serbian language, which have been created for the application of the FC in Biology in primary school, the effects of this teaching approach on the achievements of primary school students in Serbia are still unknown. Also, there are few empirical researches examining the educational efficiency of the FC, taking into account the performance of the students and their invested mental effort in solving tasks, as well as the students' involvement in applied teaching approaches.

With the intention to address the mentioned gaps, the aim of this research is to determine efficiency and students' involvement in the flipped Biology classroom, compared to the CC approach. Efficiency and students' involvement are measured by combining the values of the students' performance and mental effort invested in solving tasks on the test.

A Theoretical Framework

The flipped classroom teaching approach, which is a more and more widespread present-day model of learning and teaching in classrooms around the world, was first applied as an innovative model by two teachers, Jonathan Bergmann and Aaron Sams, in their Chemistry classes, in 2007. By flipping Chemistry teaching, with students watching video lectures at home and doing homework at class under their supervision, Bergman and Sams realized that not only did the grades of the students increase, but that there was more time remained for various types of activities which contributed to deeper understanding of the material than ever before (Bergmann & Sams, 2009). By promoting this teaching approach at schools and Universities around the world, developers of the FC model have inspired a great number of teachers to apply this approach in their teaching disciplines, such as Science, Technology, Engineering, and Mathematics (Eichler & Peeples, 2016). Accordingly, this approach has become a prevalent teaching model in the United States (Warter-Perez & Dong, 2012).

The FC approach includes two main parts: pre-class and in-class activities. The nature and design of these activities varies among different studies, and is currently being debated (Bouwmeester, de Kleijn, Ten Cate, van Rien, & Westerveld, 2016; Hurtubise, Hall, Sheridan, & Han, 2015; Moffett, 2015; O'Flaherty & Phillips, 2015; Sharma, Lau, Doherty, & Harbutt, 2015). *Pre-class activities* involve students who view web lectures, link to scientific papers, link to additional electronic books, perform the target reading from the textbook, solve formative test questions, solve online reading quizzes (Bouwmeester et al., 2016; Moraros, Islam, Yu, Banow, & Schindelka, 2015; Morton & Colbert-Getz, 2017; Prober & Heath, 2012; Roehl, Reddy, & Shannon, 2013; Wilson, 2013). According to Hamdan, McKnight, McKnight and Arfstrom (2013), students are usually provided with the teaching content before coming to class via online video or audio recordings of lectures, Internet resources, and/or slide presentations with audio narratives. Bishop and Verleger (2013) have also pointed to the importance of using digital technology in the teaching activities outside the classroom. *In-class activities* generally include the case-study teaching method followed by a discussion based on new case studies (Bouwmeester et al., 2016; DeRuisseau, 2016), team-based learning exercises in order to apply deep learning of the subject matter (McLaughlin et al., 2014; Moraros et al., 2015; Strayer, 2012), Lymans' "think-pair-share" teaching strategy (Morton & Colbert-Getz, 2017), and quizzes as a part of the discussion (Tune, Sturek, & Basile, 2013). In such student-centred learning environments, teachers maximize the classroom time in order to guide students in solving problems, provide differentiated instruction, and provide students with an environment where an abundant social interaction can occur.

The flipped classroom is a phenomenon that is spread rapidly at schools and universities around the world, also attracting a growing body of the research. Most of the papers are focused on how to implement the FC in higher education settings and examine the effects of using this approach in comparison to the traditional lecture approach (Hultén & Larsson, 2016). For example, compared to the lecture classroom, Morton and Colbert-Getz (2017) have found that the FC could help increasing the students' performance in higher-order learning outcomes better than in the classroom lecture. These authors point out that the FC approach may be the most beneficial in facilitating the students' ability to analyse the teaching material in the undergraduate medical education. Cheng, Ka Ho Lee, Chang and Yang (2017) have found that the FC contributes to a better performance and improves histology

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education among medical students. Strayer (2012) has concluded that the FC students are more open to cooperation when compared to lecture-homework classroom students both for their preferred learning environment and their actual classroom experience. Tune et al. (2013) have emphasized that the FC model significantly improves the first-year graduate students' performance in cardiovascular, respiratory, and renal physiology compared to a traditional lecture-based model. They suggest that the use of homework and in-class quizzes is a critical motivating factor that contributes to better participation of students in the classroom discussions. The FC model provides the instructors with significantly more class time to emphasize important concepts and/or engage students in the problem-solving exercises, while retaining the assurance that the students have received important background information provided by the didactic lectures (Tune et al., 2013). Comparative studies of researchers (Fautch, 2015; Stockwell, Stockwell, Cennamo, & Jiang, 2015; Street, Gilliland, McNeil, & Royal, 2015; Wong, Ip, Lopes, & Rajagopalan, 2014) have also found positive trends in a flipped environment over a traditional environment. Although a great number of researchers point out the FC as a good alternative to traditional classroom, there are also few studies that have shown no difference of the students' performance in the FC compared to the lecture classroom (McLaughlin et al., 2013). In a study conducted by Moffett and Mill, 2014, findings suggest that students who have studied the complete Veterinary Medicine course in a traditional classroom are significantly better in their performance on both levels (knowledge and application) on the final test, compared to the students from the flipped classroom.

Despite considerable publicity and obvious advantages of the FC in secondary and higher education, this approach to date has garnered a limited scholarly research in its use in primary education (Hultén & Larsson, 2016), including the Biology teaching. Besides, most of the aforementioned researchers examine the effectiveness of the teaching approach taking into account only one dependent variable, the students' achievement, considering as more effective the teaching approach that provides greater students' achievement. However, for more valid evaluation of the efficiency assessment of the considered teaching approach, Paas, Tuovinen, Tabbers and Van Gerven (2003), as well as Tuovinen and Paas (2004), propose a combined approach that includes a comparative measurement of the students' achievement and the mental effort invested in solving tasks.

In addition to mental load and performance, the mental effort is a measurable dimension of a cognitive load. The cognitive load is a burden imposed on the cognitive system of an individual when learning a new teaching content, or when solving a particular problem or task (Paas & van Merriënboer, 1994; Sweller, van Merriënboer, & Paas 1998). Mental load is exclusively related to the demands of the task and the environment. On the other hand, the mental effort refers to the capacity size of the working memory which is dedicated to adapting to the requirements of the task, and as such, the mental effort depends both on the characteristics of the task and the characteristics of the educational method (Kalyuga, 2009; Plass, Moreno, & Brünken, 2010; Sweller, 1994; Sweller, Ayres, & Kalyuga, 2011). Thus, a measurement of the mental effort can reveal important information about the actual cognitive load of an individual (Sweller et al., 1998). By combining the values of the students' performance and the mental effort invested in solving tasks on a knowledge test, it is possible to estimate relative efficiency (E) of teaching approches (Paas & van Merriënboer, 1993). In the later research, Paas, Tuovinen, Van Merriënboer and Darabi (2005) elaborate that the combined mental effort and performance scores can be calculated and visualized in the relative involvement (I) of students in the teaching approach.

Considering the involvement of students in different educational conditions, this can be used to compare the efficiency of teaching approaches on the students' motivation to learn specific contents. Motivational effects affect the students' decision to learn and do exercises, as well as the mental effort, which is invested in mastering the material. If the student is not interested in the content or the task, he/she will not invest enough mental effort to learn the teaching material, which will result in his/her low performance. When the student's involvement is higher in a particular educational condition, more mental effort is likely to be invested, and this is likely to result in higher performance (Paas et al., 2005).

In order to achieve a more comprehensive insight into the efficiency of the applied teaching approach, Figure 1 shows a combined graph interpretation of the measures of educational efficiency and students' involvement.

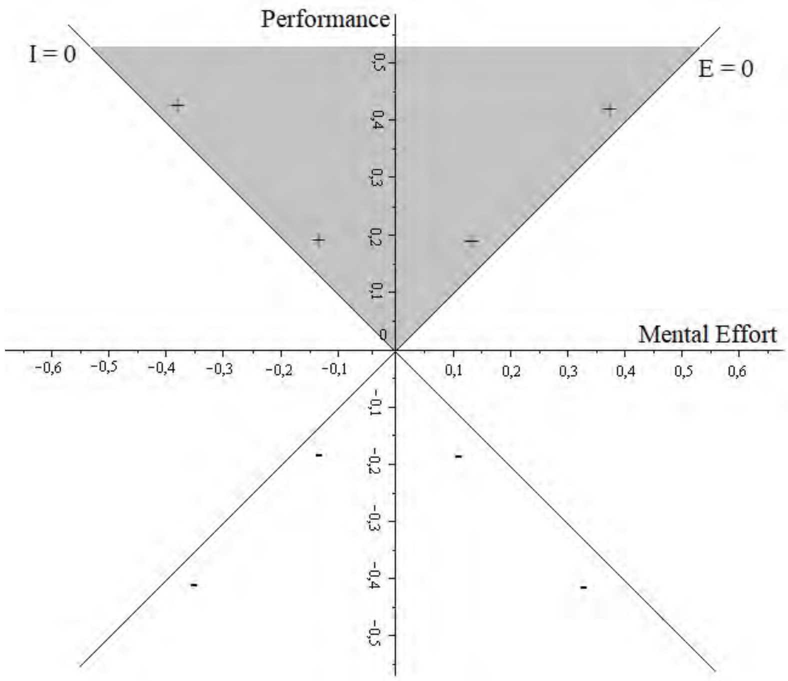

Figure 1: Graph representation of educational efficiency and the students' involvement (adapted according to Cerniglia, 2012).

On Figure 1, the upper part of the graphic representation, which is shaded and bordered with intersecting lines, points to the educational conditions that provide students with maximum performance efficiency in solving complex cognitive tasks. The lower part of the graphic representation, which is bordered with intersecting lines, points to the poor efficiency of educational conditions (Cerniglia, 2012).

Starting from the literature quotations that the number of papers on the FC in primary education is deficient, the aim of this research is to determine efficiency and students' involvement in the flipped Biology classroom in primary school (within the contents 'Urinary and Reproductive System in Humans'), compared to the CC approach.

Research Questions

In accordance with the stated aim, the following research questions were formulated:

1. Does the FC approach reduce the students' mental effort that needs to be invested while solving problems in the field of Urinary and Reproductive System in Humans?
2. Does the FC approach increase the students' performance in the field of Urinary and Reproductive System in Humans?
3. Which applied teaching approach result in the higher value of educational efficiency and student's involvement?

Methodology of Research

General Background

Experimental approach was used in this research. According to the aim of the research, the pedagogical experiment was conducted with parallel groups. Students from the experimental group (E) learned the contents of the 'Urinary System and Reproductive system in Humans' within the Biology classes for the seventh grade by using the FC teaching approach, while at the same time, the students of the control group (C) learned the same

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contents in the conventional way. The two groups were then evaluated to identify effects of the applied teaching approaches on the students' performance and their assessment of invested mental effort.

Sample

The convenience sample consisted of 112 students from two primary schools in Novi Sad, Serbia, who participated in the research. In order to calculate the sample size, the application http://www.raosoft.com/samplesize.html was used. The entire population of all seventh-grade students of primary schools from Novi Sad was around 1,700 students. For the value of margin of error between 5% and 10%, research sample of 112 students represented a convenience sample. Also, in order to obviate a potential influence of another teacher on the results of the research, there were selected schools where one the same teacher teaches. In total, every group (E and C) consisted of 56 students. In C group there were 25 boys (44.6%) and 31 girls (55.4%), while in E group there were 32 boys (57.1%) and 24 girls (42.9%). The age of the seventh-grade students was from 12 to 13. Prior to the start of the research, it was established that there was no student in the experimental group who did not have both a computer and Internet connection at home, which enabled them to participate in the research.

Instruments and Procedures

The experiment was carried out in the school year 2015/2016, during regular Biology classes, on the contents of the subtopic 'Urinary system and Reproductive system in Humans', in the second semester of the seventh grade of primary school. The students in the E and the C groups were taught by the same Biology teacher. The overview of the contents taught to the students in both groups during the pedagogical research is presented in Table 1.

Table 1. The contents taught to the students in the E and C groups.

Subtopic	Teaching units
Urinary System in Humans	1. Overview of the diversity of the urinary system in animals; The structure and function of urinary organs; Diseases of urinary organs. 2. The structure of kidneys (dissection) - Study of the outer appearance and anatomical structure of the pig kidney. 3. Repeat the material.
Reproductive System in Humans	1. Overview of the diversity of the reproductive system in animals; The structure and function of reproductive organs; Physiology of reproduction. 2. Inheritance of sex in humans; Hereditary diseases related to sex; Diseases of the reproductive organs; Hygiene of genitals. 3. Repeat the material.

The work with students from both groups encompassed a total of six regular class periods, each lasting 45 minutes. Within this period, 3 classes were given to students to analyse the teaching material, 2 classes were foreseen to repeat the contents, and 1 class was foreseen for the implementation of the exercise (Table 1).

At the beginning of the research, at the regular Biology class, prior to teaching the subtopic 'Urinary system and Reproductive system in Humans', both the experimental group and the control group of students were tested with the pre-test in order to synchronize the previous knowledge of students in both groups. Pre-test in both groups of students was carried out the same day. The pre-test contained 18 tasks of multiple choices type related to the following teaching subtopics: Circulatory System, Respiratory System, and Digestive System in Humans. Every correctly solved task was scored one point, so the maximum possible achievement on the pre-test was 18 points. After pre-testing, teaching of the subtopic 'Urinary system and Reproductive system in Humans' was implemented with different teaching approaches: the FC approach in the E group and the CC approach in the C group.

The flipped classroom approach comprised two educational components: pre-class and in-class activities. In pre-class activities, before every class foreseen for analysing the new teaching material, the students were obliged to view short video clips that represented a 10-15 minute comprised lesson, which understanding would be deepened at class. Video lectures assigned to the E group students immediately prior to the experimental research were recorded by using Screencast-O-Matic software. This software captured all the activity on the screen, including a PowerPoint lecture slide background, a small picture of the teacher's face (captured while "lecturing"), any drawing or annotation done over the lecture slide, and sound at the same time when the screen activity was recorded. In addition to the obligation to watch the entire video clip, in the context of the pre-class activities, every student had to perform certain tasks written on the worksheet related to the video material that was watched. An example of the worksheet is presented in Appendix 1. The sample of the research consisted only of students who regularly brought worksheets on all Biology classes, which were filled in on the basis of the viewed video recordings. The worksheets differed among the students, although not essentially, with the aim of ensuring the students autonomy in work rather than passing responses for others to use. A concise lesson on the video clip could be watched and listened at home or in some other place unlimited number of times, according to the individual needs of the students, in order to overcome the essence of the teaching material and solve the instruction sheet. Within the pre-class activities, prior to the class scheduled for the implementation of the 'Kidney Dissection' exercise, the students were asked to watch a video clip with the teacher's demonstration of the pig kidney dissection with the accompanying explanation of its morphology and anatomy, and then to answer the questions from the Instruction sheet. In in-class activities, at classes foreseen for the analysis of the lesson, i.e. on the lecture days, as well as on the implementation of the exercise, the teacher did not waste time on the content analysis and demonstration of the exercise, but the emphasis was on encouraging deep understanding of the lecture material. At the beginning of the class, in the introductory part (ten-minute duration), the teacher checked the students' mastering of the given recorded content via presentations of the students' response to the tasks from the Instruction sheet. This part of the class was also reserved for the students' questions regarding the assigned pre-recorded lecture material. They were allowed to ask for clarification of certain parts of the lesson, as well as to discuss its interesting parts. After the initial period of class time, there were given 25 minutes to the students in small groups (four to five people), who had a task under the teacher's management to actively approach solving of the problem tasks through a joint discussion, enabling them to expand and deepen knowledge about the content that was studied. For example, if the teaching unit was the 'Inheritance of Sex in Humans', the students were asked to discuss in small groups how X and Y chromosome influenced the development of sex in the offspring, why some diseases were transferred from fathers only to daughters and not to sons, why the sons were more prone to some diseases (Daltonism) than their daughters, etc. Each student group was given similar tasks on the common topic, and after a short while, each group was asked to present their answers to the class so that everyone benefits from their efforts. In the final part of the lesson (ten-minute duration), the teacher organized a 10-question quiz to provide a common discussion of the peers about the realized topic of the class, deepened the discussion, and stimulated the development of conceptual abilities of the examined topic at class. Within the in-class activities at the exercise class, the students independently performed the dissection of kidneys, and then as at other classes, they deepened their understanding of its functioning and relevance to the human body through problem tasks.

Conventional classroom approach in the C group included frontal lectures, discussion and intermittent asking questions by the teacher, and responding by students in the classroom. Teaching aids and devices used in the research were the PowerPoint Slides, textbook, blackboard and chalk. On lecture days (during classes when analysing the teaching material), while the teacher was lecturing, the students wrote the most important theses. At class when implementing the exercise 'Kidney Structure (dissection)', after the teacher's performance of the kidney dissection, students organized in groups were repeating, drawing, and marking parts of the kidneys. Their homework was to answer the questions given in their Biology textbook.

Upon completion of the analysis of the teaching subtopic 'Urinary System and Reproductive system', students from both groups took the post-test the same day. The post-test contained 18 tasks of multiple choice type. Each correctly solved task in the post-test was scored one point. Accordingly, the maximum possible performance score on the test was 18 points. Within each task of the post-test, except in the content questions, students were asked to evaluate the mental effort they invested during their solving the tasks. They evaluated the mental effort by selecting one of the offered descriptors on the 5-point Likert scale. The descriptors were coded in the following way: very easy (code 1), easy (code 2), neither easy nor difficult (code 3), difficult (code 4), very difficult (code 5). Examples of several tasks from the post-test are presented in Appendix 2. Therefore, the goal of the post-test was to measure the performance of students from E and C groups regarding the teaching subtopics 'Urinary System and Reproductive system in Humans', as well as the mental effort invested by students of both groups in solving tasks.

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Ethical Considerations

The consent of the school principal, Biology teacher, and the school board, was obtained for the implementation and realization of the research from each school. All students who were a constituent part of the research sample voluntarily accepted their participation in it. They were introduced to the possibility of their own exclusion from the research at any time of its implementation without having any consequences.

Data Analysis

The mean score and standard deviation on the pre-test, the post-test and the invested mental effort were determined for both groups. The *t* test was used for testing difference in students' scores and invested mental effort between FC and CC groups. Additionally, a procedure described by Paas and Van Merriënboer (1993) was followed for the calculation of efficiency of the FC and CC approaches, while the procedure described by Paas et al. (2005) was followed for the calculation of students' involvement in applied educational approaches. Data were analyzed using SPSS 12.0.

Research Results

Students' Performance on the Pre-test

Table 2 contains the descriptive statistics of the pre-test, and the corresponding *t* value.

Table 2. Descriptive statistics and the t value for performance on the pre-test.

Group	N	M	SD	df	t	p
E	56	9.41	3.01	110	-.135	p>.05
C	56	9.48	2.59			

As it could be seen in Table 2, there was no statistically significant difference in the mean score of the students in the two groups determined on the pre-test. On the basis of the performances accomplished on the pre-test, E and C groups were equalized according to the students' knowledge on circulatory, respiratory, and digestive systems of humans.

Students' Assessment of Invested Mental Effort during Solving the Post-test

Table 3 contains statistical parameters obtained for the students' assessment of invested mental effort on the post-test.

Table 3. Descriptive statistics and the t value for students' invested mental effort on the post-test.

Group	N	M	SD	df	t	p
E	56	2.52	1.01	110	-8.55	p<.001
C	56	4.00	0.80			

Looking at the results for the students' assessment of invested mental effort (Table 3), students in E group stated that less mental effort was needed to be invested in order to solve the test tasks than students in C group. The obtained values (for E group: 2.52; C group: 4.00) clearly indicated that the students' mental effort was less when students learned Biology based on the flipped classroom approach than when learning the same content based on the CC approach. These data pointed to the advantage of the FC in terms of a smaller take-up of space in the students' working memory, which facilitated the adoption of teaching materials.

Students' Performance on the Post-test

Table 4 contains statistical parameters obtained for performance of E and C groups.

Table 4. Descriptive statistics and the t value for performance on the post-test.

Group	N	M	SD	df	t	p
E	56	15.40	2.60	110	11.33	p<.001
C	56	10.07	2.36			

As it could be seen in Table 4, the students in E group who invested less mental effort when solving the tasks achieved a significantly higher mean score on the post-test (85.52%), in comparison to the students in C group (59.23%). The obtained results indicated the advantage of the application of the teaching approach based on the principles of the flipped classroom, in terms of better achievement of students about the urinary and reproductive systems in humans compared to the CC approach.

Educational Efficiency and Students' Involvement in the FC and CC Approaches

In this research, by combining the values of the students' achievement and their assessment of mental effort invested during the problem solving in the final knowledge test, there was calculated a relative educational efficiency, and the students' involvement as a motivational perspective of students for learning in the FC and the CC approaches.

Figure 4 shows a graph of educational efficiency and the students' involvement in the FC and CC approaches.

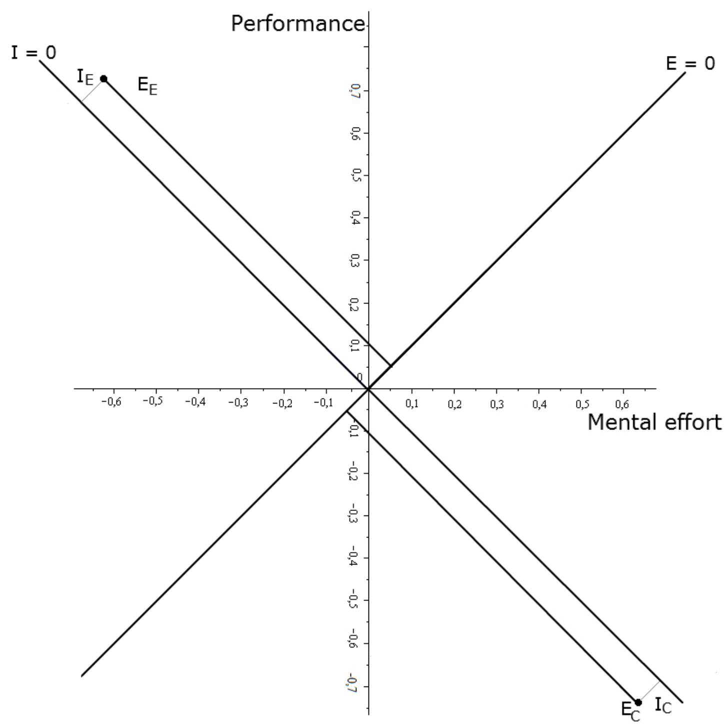

Figure 4: Graph of educational efficiency for the FC and CC approaches.

As shown in Figure 4, the obtained values for the educational efficiency of the FC (E_E= 0.964), and the involvement of the students' E group (I_E= 0.07) are found in the upper left quadrant, while the obtained negative values

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for the CC approach (E_C= -0.964; I_C= -0.07) are found in the lower right quadrant. Using the principles outlined in the introduction, the obtained positive value for the involvement indicates a greater interest of students in resolving the post-test tasks, which led to lower mental effort and resulted in their high post-test performance. On the other hand, the obtained negative value for the students' involvement in the CC approach indicates a lower interest of students in resolving the post-test tasks, which induced their higher mental effort, and thus the lower achievement in the post-test.

Discussion

In this research, there have been compared the educational efficiency and students' involvement of the FC with the CC approach in Biology teaching in primary school.

The first result indicated that the application of the FC approach in Biology teaching required less mental effort of students when solving the tasks than in the CC approach. Less invested mental effort of students from the E group on the post-test could be foreseen for several reasons. One of them applied to pre-recorded lectures which students used in pre-class activities. The students could use pre-recorded lectures as often as possible depending on their needs and individual abilities, whether for preparing class, clarifying concepts, completing their homework, or reinforcing the concepts. Recent findings pointed to this general usefulness of the pre-recorded lectures (Eichler & Peeples, 2016; Smith, 2013). Additionally, the students from the E group had the opportunity in the introductory part of the class to ask questions to the teacher on the assigned lecture material in order to make themselves clearer and understand the contents. At class, along with constant interaction of students, as well as with the interaction between the students and the teacher, the students were encouraged and more opened to ask questions, express their opinions about the set problems, discuss the content, which was largely missing in the traditional learning environment. The advantage of the flipped pre-lecture learning environment in a domain of the cognitive load theory was highlighted by Seery (2015). He stated that learning new contents in a traditional lecture environment was limited because the delivery of the contents and extraction of information by the students limited the capacity for learning new information (Seery, 2015). By providing the students' access to the content in pre-class activities at any time, at the desired location, their mastering of the content at a desired pace, extracting the new information in a more favourable, free, interactive atmosphere at class (compared to the pre-survey period) probably led to a reduction in mental effort. This research also agrees with the results of other researchers (Ayres, 2006; Mayer, 2008) who suggest that pre-learning may be an effective means to reduce the cognitive load for students, thus facilitating learning.

The second result indicated that students who learned Biology content using the FC approach were better at the post-test, compared to students who taught the teaching contents in the conventional way. It was expected that a successful mental integration of pre-class and in-class activities of the FC during learning should improve the test performance. Students' performance was measured by using a multiple-choice test, and the test results showed that performance scores of the FC group were significantly higher than those of the CC group. Therefore, it is possible to assume that students learn Biology contents better and with more understanding when they are prepared for class, and when they approach learning concepts and skills interactively. These findings are supported by the research findings (Alvarez, 2012 in Math, Science and Social Studies; Cheng et al., 2017 in Histology; Day & Foley, 2006 in the computer interaction course; Tune et al., 2013 in Cardiovascular, Respiratory and Renal Physiology) that the application of the FC in different educational fields in secondary school and higher education significantly improve academic performance and the students' grades.

Finally, the third result indicated that the students' involvement and the educational efficiency in the FC group was higher than in the CC group. The students' involvement and the educational efficiency were assessed by the Paas et al., (2005) and Paas and Van Merriënboer (1993) with the computational methods. The researchers applied in their works a combination of values of mental effort and students' performance for assessing the educational efficiency of various innovative approaches (Mattis, 2015; Milenković, Segedinac & Hrin, 2014; Radulović & Stojanović, 2015; Radulović, Stojanović, & Županec, 2016; Salden, Paas, Broers, & Van Merriënboer, 2004). Applying these methods, which involved the combination of values of the intensity of mental effort invested by the students with the obtained task performance, this research has shown that the FC increases the students' involvement and educational efficiency. Research on active learning strategies (Freeman et al., 2014; Prince, 2004) supported the effectiveness of the FC in increasing the students' learning and achievement. The FC approach applied in this research (as described in the section Instruments and Procedures) provided students with greater engagement, which led to their greater success compared to the CC approach. At Biology classes, the teacher ensured that students spent more than half a time at class to actively solve problems, answer questions, talk to each other about the topic studied, creating an exciting atmosphere with the discussion that encouraged the students' participation. The obtained positive values of the students' involvement in the flipped conditions indicated that they were more interested in solving tasks. By increasing the students' motivation for solving the tasks, there was increased their confidence that they were capable to solve the task. Our results that indicated the positive impact of motivational effects on the students' achievement are in agreement with the results of other researchers (García, Rodríguez, Betts, Areces, & González-Castro, 2016; Greene, Miller, Crowson, Duke, & Akey, 2004; Juriševič, Glažar, Pučko, & Devetak, 2008; Steinmayr & Spinath, 2009).

The obtained positive values of the educational efficiency and the students' involvement indicate the high efficiency of the FC teaching model in Biology in primary school, as it causes less mental load, greater motivation and greater achievement. Nevertheless, having in mind the research results which show no difference in performance for students in the FC, compared to the traditional classroom in related biological disciplines (Galway, Corbett, Takaro, Tairyan, & Frank, 2014 in Public Health course on Environmental and Occupational Health; McLaughlin et al., 2013 in Pharmaceutics course; Whillier & Lystad, 2015 in Neuroanatomy course; Wong et al., 2014 in Pharmacy Cardiac Arrhythmias course), as well as the increase in the students' performance in a traditional intersection compared to the FC (Moffett & Mill, 2014 in Veterinary Medicine course), it is necessary to continuously conduct research on the effects of the FC in the Biology in primary school in order to make valid conclusions, recommendations and strategies relevant for its implementation in the teaching process.

Conclusions

This research is significant because it provides experimental evidence that the use of FC in Biology teaching in primary school contributes to more efficiency and students' involvement compared to the CC approach. Students who learned the Biology contents by using the FC approach achieved greater achievement on the knowledge test with less invested mental effort. This is especially significant in the time of the rapid development of Biology as a science, which inevitably leads to be a burden of the Biology curricula.

Taking into account several limitations of this research, its findings and significance, it is necessary to carefully interpret it considering the following issues. First, a three-week intervention is a rather short period for examining the efficiency of a teaching approach. Although the obtained research results are very encouraging, this research lacks effects of the FC on the knowledge retention. Further limitations are reflected in the research sample and investigated contents, since this research has included only two primary schools and contents of two organic systems (Urinary and Reproductive System) from the teaching topic 'Structure of Human Body' for the seventh grade of primary school in the Republic of Serbia. Thus, future empirical research should be focused on investigating the possibilities for implementing the FC in other Biology topics in primary school, on a larger sample, where the duration of the intervention should be at least one semester. It would be important to examine how the FC influences higher order thinking of primary school children.

Taking into account the positive empirical evidence on the application of the FC in the Biology teaching in primary school despite some limitations, this research suggests several implications for educators. The implementation of this teaching strategy requires from Biology teachers to upgrade their knowledge and skills in using the modern technology. It is necessary for video lessons used by the students as a preparation for class to be easily accessible for the students at any time. Video lessons recommended for students to be viewed in pre-class activities should be interesting, should keep the students' attention and activate their functional knowledge and skills. These findings confirm that by using the FC approach, the teacher should integrate the pre-delivered lessons with as many interactive in-class activities as possible, which imply a small group discussion, problem-solving, or performing experiments.

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Appendix 1. Worksheet for implementation of the teaching unit: Overview of the diversity of the urinary system in animals; The structure and function of urinary organs; Diseases of urinary organs.

I. On the line next to the listed group of animals, write the name of the organ by which the animals remove the harmful substances from their body.

Sponges: ____

Coelenterata: ____

Flatworms: ____

Molluscs: ____

Vertebrates: ____

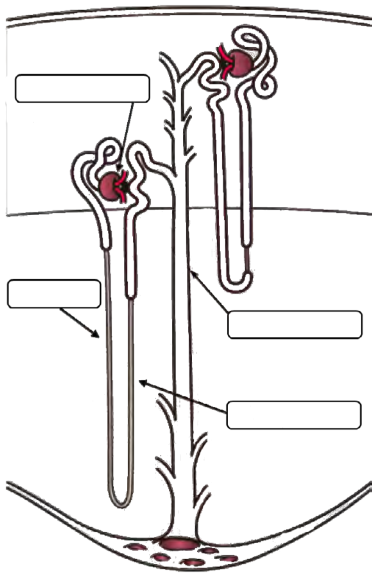
II. Circle the letter of the correct answer.

1. Which of the following organs does not belong to the urinary system?
   a) spleen
   b) ureter
   c) kidneys
   d) urinary bladder
   e) urethra

2. The structural and functional unit of the kidney is:
   a) an axon
   b) a neuron
   c) a nephron
   d) a dendrite

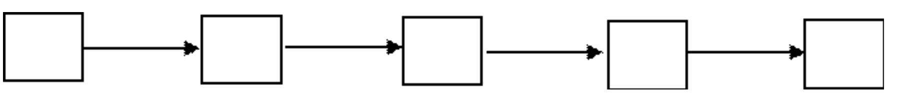
3. Primary urine of the healthy persons consists of:
a) water, hormones, uric acid, leukocytes...
b) water, blood elements, urea, glucose, vitamins...
c) water, mineral salts, ammonia, thrombocytes ...
d) water, vitamins, sugars, urea, poisons....
e) 96% uric acid and 4% nutrients, poisons, inorganic salts, vitamins

III. Write the names of the marked parts of the nephron into the blank fields in the picture.



IV. Write the letters into the blank fields so that the resulting sequence of activities describes the way of emptying the urinary bladder when it is filled with more than 350 mL of urine.

a) nerve impulses arrive in the central nervous system
b) wall of the urinary bladder stretches
c) pressure receptors are activated in the wall of the urinary bladder
d) urine passes through the urethra
e) the wall of the urinary bladder is being contracted, releasing the circular muscle at the bottom of the urinary bladder.



V. Circle the letters of the correct answers.

For the proper functioning of the kidneys, it is necessary to avoid entering larger amounts of:

a) salt
b) water
c) fruit
d) vegetables
e) alcohol

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Appendix 2. Examples of several tasks from the post-test

Circle the letter of a correct answer, and then assess how difficult the task was.

1. Which substances listed below contain secondary (final) urine of the healthy human?
a) sugar and water
b) proteins and fat
c) urea and water
d) vitamins and sugar

Very easy	Easy	Neither easy nor difficult	Difficult	Very difficult

2. Gametes of a healthy human contain:
a) 22 autosomes and one allosome
b) 22 autosomes and one allosome pair
c) 23 allosome
d) 21 autosomes and one allosome pair

Very easy	Easy	Neither easy nor difficult	Difficult	Very difficult

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