

# Factors Influencing the Frequency of Use of Inquiry-Based Approach to Teaching Primary Science

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## Abstract

*This paper presents results of a study whose aim was to determine whether there is a connection between the frequency of use of inquiry-based approach to teaching primary science and teachers' attitudes towards the importance of this type of instruction, as well as their personal experience of participating in different forms of inquiry-based learning during their own formal education and training. The research was conducted using a sample of 275 elementary school teachers (grades 1 to 4) in the City of Zagreb and Zagreb County. The results indicate a statistically significant difference in the importance attributed to inquiry-based science instruction, frequency of its practical implementation, and personal experience with inquiry-based learning. Despite teachers' positive attitudes towards inquiry-based science instruction, the results have shown that it is not implemented in practice frequently enough, and the respondents only rarely experienced inquiry-based learning during their formal education. It has been observed that the teachers who attribute greater importance to inquiry-based science instruction and who had a more intense experience with inquiry-based learning during their formal education organize their classes in this manner more frequently. The obtained results suggest that it is important to shape positive attitudes of future teachers towards inquiry-based teaching. It is necessary to involve them in inquiry-based forms of learning during their initial teacher training more systematically so they can implement them more efficiently and more confidently in their own teaching practice, on the basis of competences they acquired in such a way.*

**Key words:** *frequency of implementation; inquiry-based learning; science instruction; teachers' attitudes.*

## **Introduction**

Implementation of inquiry-based instruction in the daily teaching practice depends on numerous teacher-related factors. One of them is teachers' attitude towards inquiry-based teaching and curriculum recommendations regarding the need for inquiry-based learning (Sarason, 1971; Saylor & Alexander, 1974; Shkedi, 2006, as cited in Chan, 2010; Yeung, 2000). Numerous research studies have determined that teachers' decisions regarding the implementation of different teaching strategies in their daily teaching practice are mostly governed by a complex mixture of their personal beliefs and knowledge (Bryan & Abell, 1999; Clark & Peterson, 1986; Richardson, 1996; Tobin, Tippins, & Gallard, 1994), as are their decisions to implement inquiry-based instruction. Anderson (2002) especially emphasises that the majority of difficulties associated with the implementation of inquiry-based instruction stem from a teacher's value system and his or her views regarding students, teaching and the purpose of education. If a teacher's value system is built upon a learning and teaching experience which does not coincide with the objectives of inquiry-based teaching, it can lead to the development of negative attitudes towards that type of teaching (Blanchard, 2006; Eick & Reed, 2001; Wallace & Kang, 2004). Such teachers are less likely to change their existing teaching habits, unlike teachers whose convictions coincide with the objectives of inquiry-based teaching and who are open towards changing the manner in which they work. It is therefore useful to identify those views which have a negative impact on the implementation of inquiry-based instruction, in order to be able to change them.

Apart from a positive attitude towards inquiry-based teaching, another important factor influencing the implementation of inquiry-based instruction is the teacher's knowledge of its main components. This means that a successful implementation of inquiry-based instruction requires teachers to have a deep and thorough knowledge of the subject matter that they teach, the learning process, and the manners in which to support students' research activities. National Science Education Standards [NSES] (National Research Council, 2000) especially emphasise that the level of teachers' familiarity with the inquiry-based learning process and inquiry methods are the basic prerequisites for understanding scientific inquiry and its implementation in science instruction.

Despite recommendations set forth by educational documents which advocate the need to implement inquiry-based teaching, it has been established that numerous teachers, and especially those who have only just completed their teacher education studies, do not feel trained enough to implement inquiry-based instruction (Rohering & Luft, 2004). Teachers often recognize the importance of inquiry-based instruction, but they are faced with difficulties in its implementation (Levitt, 2001). Therefore, we often discuss the obstacles to implementing inquiry-based lessons (Moscovici, 1999). Some of the reasons for insufficiently frequent use of inquiry-based teaching in educational practice are the following: teachers' lack of experience with participation in inquiry-based instruction during their initial teacher education; insufficient number of professional trainings for teachers, which would allow them to participate in research;

and professional trainings in inquiry-based instruction which are mainly focused on the product of scientific inquiry rather than on the process of scientific inquiry. Clearly, it would be unrealistic to expect teachers to understand and implement inquiry-based instruction after having simply read educational documents which describe this type of teaching or having attended lectures on scientific inquiry. In this way they can acquire knowledge on what scientific inquiry is and how to conduct it, but only an immediate experience with scientific inquiry can allow them to grasp science in its entirety. Therefore, such activities should be organised both during teachers' initial education and during their professional training (Westerlund, Garcia, Koke, Taylor, & Mason, 2002).

According to Bybee (1997), apart from mastering the skills of applying natural science methods such as observing, inferring and analysing data, a teacher also needs to possess a deep understanding of scientific concepts to successfully implement inquiry-based science instruction. This understanding and skills should be combined with scientific knowledge and scientific way of thinking, as well as with corresponding pedagogical, psychological, didactic and methodological competences (Loucks-Horsley, Hewson, Love, & Stiles, 1998). This means that the implementation of inquiry-based teaching requires not only knowledge of scientific methodology but also knowledge of the subject matter of the scientific discipline in question, and pedagogical and psychological principles of teaching (Hart, 2002; Schwab, 1964; Shimoda, White, & Fredericksen, 2001; Tobin, Tippins, & Gallard, 1994; Yerrick, 2000). If teachers lack one of these main components, or if they are not sufficiently familiar with the scientific methodology, they will not be able to implement the inquiry-based approach properly.

Smith and Neale (1989) and Lee, Hart, Cuevas, and Enders (2004) also claim that teachers' fundamental knowledge is a significant factor influencing the translation of their views about science into their teaching practice. Even if teachers have a positive attitude and views regarding inquiry-based teaching, they will not be able to properly implement inquiry-based instruction in their teaching practice if they lack teaching competences and the fundamental knowledge of the scientific discipline they teach.

NSES (National Research Council, 2000) identifies four main factors influencing a successful science instruction by means of inquiry-based teaching. The most important one is a teacher's experience related to scientific inquiry and inquiry-based learning from his or her own formal education, which can have a significant impact on the teacher's understanding of scientific inquiry. If the experience is positive, and if the teacher has had experience with the process of inquiry-based learning, his or her understanding of the process will undoubtedly be clearer and more comprehensive. Studies conducted so far have shown that teachers who participated in inquiry-based instruction during their formal education have a more positive attitude towards inquiry-based teaching and learning than those who did not have such an experience (Damjanović, 1999). The manner in which a teacher teaches is the result of his or her own training, studying and experience acquired through his

or her practical work as a teacher. Matson and Pearsons (1998) especially emphasise that teachers who have never experienced inquiry-based instruction will not be able to successfully implement inquiry-based approach in their science class. This means that it is necessary for teachers to experience inquiry-based approach even before actually organising an inquiry-based class. Duschl (1983) also believes that previous experience with scientific inquiry has a significant impact on a teacher's perception of science, and thus indirectly on his or her practice of teaching topics related to natural sciences. An active involvement in inquiry-based learning allows teachers to gain a deeper understanding of the scientific inquiry process and potential difficulties which might occur. Conversely, if teachers are trained in a traditional way, they are likely to continue applying the approach to teaching which relies on the traditional lecture-and-demonstrate paradigm.

Experiential participation in scientific activities, which takes place in research laboratories, should therefore form a crucial part of teachers' professional development. Apart from being familiar with how scientific inquiry is implemented in teaching practice, teachers should also develop their teaching skills through professional development programmes, and continuously enhance the knowledge which allows them to successfully teach about scientific inquiry.

Apart from having personal experience with scientific inquiry, it is also very important for a teacher to understand the process of inquiry-based teaching and the possibilities it provides. Teachers usually acquire such knowledge during their teacher training, and it represents a solid foundation for a successful implementation of inquiry-based instruction in their teaching practice. However, experience and knowledge acquired in the course of formal education are not sufficient for a thorough understanding of scientific inquiry. It is very important for a teacher to be research-oriented throughout his or her life, especially in his or her own professional development which should revolve around inquiry-based teaching.

A teacher's thorough understanding of scientific inquiry is positively correlated with the implementation of inquiry-based instruction, but it cannot be defined as the only prerequisite for its successful implementation in the teaching practice. It is very important to take into consideration those factors which correlate negatively with the implementation of inquiry-based instruction. By interviewing teachers, Costenson and Lawson (1986) have identified ten main factors which prevent teachers from implementing inquiry-based instruction. Among them we can emphasise the structural and temporal demands of designing a high-quality inquiry-based lesson, as well as the problem of maintaining the energy level necessary for the implementation of active forms of learning. Another obstacle is teachers' duty to cover a large amount of mandated curriculum during class, which is less time-consuming if one uses traditional forms of teaching, given that inquiry-based instruction requires much more time. Teachers also emphasise their inability to implement inquiry-based teaching due to insufficient administrative support provided by school management, students' immaturity, their own lack of training in providing this form of instruction,

the costliness of materials necessary for scientific inquiry, and a feeling of discomfort while implementing this form of teaching, because the teacher is not at the centre of the teaching process, and consequently cannot keep everything under absolute control. Considering the above-mentioned series of factors which correlate negatively with the implementation of inquiry-based teaching, Wenning (2005) considers the NSES model to be incomplete (2000) and proposes a different, more comprehensive model, along with three key factors which are crucial for the implementation of inquiry-based instruction. These are teachers' *knowledge* about research, their research-conducting *skills*, and *willingness* to implement it. Wennig's model also includes teacher's experience acquired during his or her formal education and the experience acquired in the course of his or her professional development, as well as the factors that Costenson and Lawson (1986) characterised as having a negative impact on the implementation of inquiry-based teaching.

## **Methodology**

### **Research Aim**

This paper shall present results of the research whose aim was to determine whether there is a correlation between the frequency of implementation of inquiry-based science instruction, teachers' attitudes about the importance of this type of teaching, and their experiential participation in various forms of inquiry-based learning during their own formal education.

### **Research Questions**

The following research questions have been formulated on the basis of the general research aim:

1. What are teachers' attitudes towards inquiry-based science instruction?
2. How often do teachers implement inquiry-based science instruction?
3. How frequently did teachers experience inquiry-based learning during their formal education?
4. Is there a statistically significant difference in teachers' assessment of the importance of inquiry-based science instruction, frequency of its implementation, and the intensity of experience with inquiry-based learning during teachers' formal education?
5. Does the frequency of implementation of inquiry-based science instruction correlate with teachers' views about its importance and teachers' experience with inquiry-based learning during their own formal education?

### **Respondents and Research Implementation**

The research was conducted by means of a survey, using a sample of primary school teachers of grades 1 to 4 (N=275) in the City of Zagreb and Zagreb County. The sample is largely composed of female respondents (94%), while in terms of qualification levels there is a similar percentage of respondents with level 7 (47%)

and level 6 (53%) qualifications. The sample includes 14% of teachers with 0-5 years of work experience, 11% of teachers with 6-10 years of work experience, 10% of teachers with 11-15 years of work experience, 23% of teachers with 16-20 years of work experience, and the largest portion (43%) of teachers with more than 20 years of work experience. With regard to the county in which they work, the sample is divided equally between teachers employed in schools of the City of Zagreb (50%) and of Zagreb County (50%).

### **Measurement Instruments**

To conduct this research, we used a questionnaire which was modelled on a part of the *Instrument for measuring teachers' beliefs and experiences related to inquiry teaching and learning and scientific inquiry* questionnaire by Ibrahim (2003). Items in the questionnaire have been adapted to the specific characteristics of science instruction in the first educational cycle. Thus modified, the questionnaire was used to examine teachers' views about the importance of inquiry-based science instruction, frequency of its implementation in the daily teaching practice, and the intensity of teachers' experience with inquiry-based teaching during their own formal education. A crucial difference between this instrument and the one used by Ibrahim (2003) is the five-point Likert scale which was used to assess the previously mentioned statements, whereas the original instrument used a three-point scale.

The instrument contains a total of 30 statements which the respondents assessed from the viewpoint of importance of inquiry-based science instruction (ranging from 1-extremely unimportant to 5-extremely important), frequency of its implementation (ranging from 1-never to 5-always), and intensity of experience with inquiry-based learning during respondents' formal education (ranging from 1-never to 5-always).

Reliability of the used scales, i.e. their internal consistency (Cronbach  $\alpha$  reliability coefficient) is at a satisfactory or high level (from 0.90 to 0.93) for all the used scales, which leads to the conclusion that all items are highly appropriate for the measurement of the researched concepts.

### **Results and Discussion**

The first part of the questionnaire examines teachers' attitudes and views about the importance of inquiry-based science instruction. Descriptive parameters of items have shown that teachers attribute a considerable degree of importance to inquiry-based science instruction ( $M_{total} = 123.28$ ;  $SD_{total} = 0.69$ ), as the majority of items in this part of the questionnaire have been assessed as important or extremely important ( $M = 3.63 - 4.62$ ), with a certain degree of variation in responses. Conversely, descriptive parameters of items used to assess the frequency of implementation of inquiry-based science instruction in daily teaching practice show that teachers apply the said teaching strategy only occasionally ( $M_{total} = 103.98$ ;  $SD_{total} = 0.83$ ). With regard to the assessment of intensity of teachers' experiential participation in inquiry-based

learning in the course of their own formal education, the results have shown that the majority of respondents rarely participated in this form of teaching ( $M_{total}=88.98$ ;  $SD_{total}=0.94$ ).

When we compare the arithmetic means of respondents' answers to certain items from the questionnaire (Figure 1), we can establish that teachers attribute the highest values to the importance of inquiry-based science instruction, while frequency of implementing inquiry-based science instruction in the daily teaching practice has been attributed considerably lower values. Teachers attribute the lowest values to the intensity of their own experience with inquiry-based learning during their formal education.

Using the data thus obtained, we can conclude that teachers' awareness of the importance of inquiry-based teaching is at a sufficiently high level, but there is a discrepancy between their level of awareness and their practical work. One of the reasons for this could be their own insufficient experience with inquiry-based learning during their formal education, but other factors which have been previously mentioned in the theoretical part of this paper could also apply.

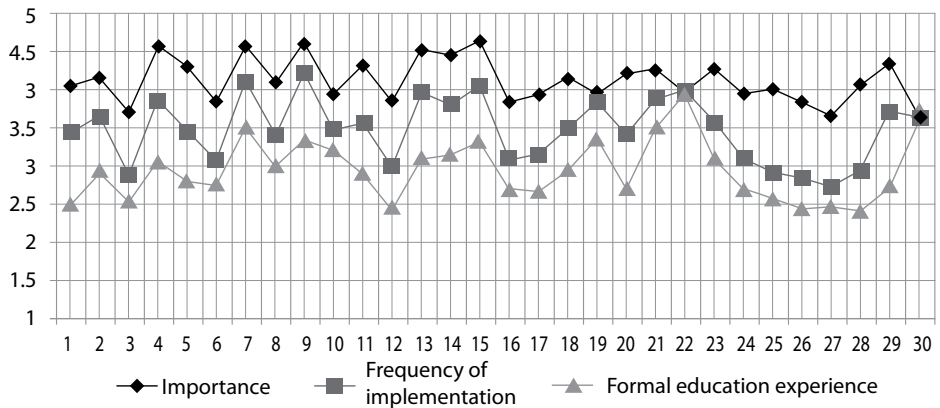


Figure 1. Compared arithmetic means of teachers' answers regarding the importance of inquiry-based science instruction, frequency of its implementation, and their experience with inquiry-based learning during their own formal education

In order to determine whether there is a statistically significant difference in the assessment of importance of inquiry-based science instruction, frequency of its implementation, and experience with inquiry-based learning during teachers' formal education, we conducted a one-way analysis of variance (ANOVA) (Table 1).

As can be seen from Table 1, the results of the analysis indicate a statistically significant difference between the above-mentioned components ( $F=939.01$ ;  $df=274$ ;  $p<0.01$ ). In order to further calculate the significance of the difference between the two groups, and taking into consideration multiple comparisons and the level of significance, we conducted a Bonferroni post-hoc test. The test has shown that respondents attribute statistically significantly higher values to the importance



of inquiry-based science instruction than to the frequency of its implementation (Bonferroni=19.31;  $p<0.01$ ) or to the intensity of teachers' experience with inquiry-based learning during their own formal education (Bonferroni=34.31;  $p<0.01$ ). Also, frequency of implementation of inquiry-based science instruction is statistically significantly higher than the assessed intensity of experience with inquiry-based learning (Bonferroni=15.00;  $p<0.01$ ).

Table 1

*Comparison of teachers' assessment of importance, implementation in teaching practice and experience from students' formal education*

	N	M	SD	F	df	p
Importance	275	123.28	0.69			
Implementation in teaching practice	275	103.98	0.83	939.01	274	<b>0.00</b>
Formal education experience	275	88.98	0.94			

Table 2

*Post hoc testing of significance of difference in teachers' assessment of importance, practical implementation and formal education experience regarding the role of students*

First comparative scale	Second comparative scale	M (1)	M (2)	Bonferroni test	p
Importance	Frequency of implementation	123.28	103.98	19.31	<b>0.00</b>
Importance	Formal education experience	123.28	88.98	34.31	<b>0.00</b>
Frequency of implementation	Formal education experience	103.98	88.98	15.00	<b>0.00</b>

The results thus obtained confirm that, despite a positive tendency in attitudes about the importance of inquiry-based science instruction, teachers working in the City of Zagreb and Zagreb County do not implement that form of teaching frequently enough.

A considerably lower level of intensity of experience with inquiry-based learning during formal education seems to indicate that the respondents have developed a positive attitude towards an active role of students in the teaching process, and that they assign such roles considerably more frequently despite the fact that they were only occasionally or even rarely exposed to inquiry-based teaching during their own formal training. This means that there is a discrepancy between their infrequent experience with inquiry-based teaching and their manner of teaching, i.e. that they are trying to follow the guidelines to organising a modern and effective science class in their own teaching practice. On the other hand, their scarce experience with inquiry-based teaching could also be the reason why teachers do not implement this type of instruction frequently enough, despite a high level of awareness about the importance of inquiry-based teaching.

In order to examine whether there is a correlation between the frequency of implementation of inquiry-based science instruction, teachers' attitudes towards



the importance of this type of teaching, and their own experiential participation in various forms of inquiry-based learning during formal education, Pearson correlation coefficient was calculated for the scales used in the questionnaire. The resulting intercorrelations are shown in Table 3.

Table 3  
*Intercorrelations between the scales used for assessing teachers' attitudes*

	Importance	Frequency of implementation	Formal education experience
Importance	/	<b>.57</b>	<b>.37</b>
Frequency of implementation		/	<b>.39</b>
Formal education experience			/

As we can see from Table 3, it is possible to establish a statistically significant correlation between teachers' attitudes about the importance of inquiry-based science instruction and frequency of its practical implementation ( $r=0.57$ ,  $p<0.01$ ). The correlation coefficient value indicates the presence of a moderate correlation, i.e. a significant correlation among results. Based on this, it can be concluded that the teachers whose assessment of the importance of inquiry-based science instruction is positive tend to organise their classes by putting the student at the centre of the teaching process more frequently and allow him or her to actively participate in all teaching situations, i.e. they implement inquiry-based science instruction more frequently. Analogously, those teachers whose assessment of the importance of this type of teaching is more negative tend to implement it less.

Furthermore, one can notice a statistically significant correlation between teachers' attitudes towards the importance of inquiry-based teaching and their experience with inquiry-based learning during their formal education ( $r=0.37$ ;  $p<0.01$ ). Those teachers who were more frequently exposed to the inquiry-based approach during their own formal education have a more positive attitude towards the importance of this type of teaching.

A statistically significant correlation has been observed between the frequency of implementation of inquiry-based science instruction and experience with inquiry-based learning during formal education ( $r=0.39$ ;  $p<0.01$ ), which leads to the conclusion that the teachers who participated in inquiry-based teaching more frequently during their formal education implement this approach to teaching more frequently in their own teaching practice.

## Conclusion

Frequency of implementation of inquiry-based science instruction is influenced by various factors, among which we can emphasise teachers' attitudes towards the importance of inquiry-based teaching and the experience with inquiry-based learning which they gained in the course of their formal education.

The results of the conducted research indicate that the attitudes of the surveyed teachers towards the importance of inquiry-based science instruction are mostly affirmative, and that teachers are aware of the positive aspects of this type of teaching. However, despite a positive perception of inquiry-based science instruction, there is a discrepancy between teachers' attitudes and frequency of implementation of inquiry-based instruction in their teaching practice, as it is still implemented only occasionally, with a moderate tendency towards an infrequent implementation. This raises the need to identify reasons for such a distribution of results, i.e. reasons for the discrepancy between the awareness of the importance of inquiry-based teaching and its practical implementation. Such results can be caused by teachers' insufficient experiential participation in inquiry-based activities during their own formal education, which can have an impact on teachers' confidence to implement this type of teaching and its infrequent practical implementation. On the other hand, these results could also have been influenced by teachers' insufficient training in pedagogical, didactic and methodological competences required for an efficient organization and implementation of this type of instruction, as well as other factors influencing the infrequent implementation of inquiry-based teaching which were not the topic of this research but have been mentioned in the theoretical part of this paper.

Furthermore, this research has confirmed the findings of previous research studies about the presence of a positive correlation among the frequency of implementation of inquiry-based science instruction, teachers' attitudes towards the importance of inquiry-based teaching, and experience with the inquiry-based approach they gained during various levels of their own formal education. Due to the fact that the teachers who attribute more importance to inquiry-based science instruction and those who have had a more intense experience with inquiry-based learning during their formal education tend to organise their lessons in this manner more frequently, there is a need to involve future teachers in inquiry-based forms of learning during their initial teacher training more systematically, as this would allow them to implement such an approach to teaching more effectively and with more confidence in their own teaching practice. Furthermore, it is also necessary to organize training and professional development of teachers in theoretical aspects of the process of inquiry-based teaching, and especially of its practical implementation in science instruction, which requires specific pedagogical, didactic and methodological competences.

It should also be emphasised that practical implementation and teachers' willingness to implement inquiry-based teaching remains an individual choice. Although modern curricula and syllabi support and recommend inquiry-based instruction, its practical implementation is still not sufficiently widespread, which is why future endeavours should focus on increasing the popularity and implementation of this form of teaching.

A high-quality implementation of this type of instruction in one's teaching practice requires professionally trained teachers who will possess not only theoretical knowledge of inquiry-based teaching but also have experience with inquiry-based

learning and highly developed competences for its effective implementation. Therefore, apart from direct experience with inquiry-based teaching, teachers' initial education and professional training should also provide an opportunity to reflect on the context of inquiry-based learning (Blanchard, 2006), which would contribute not only to the understanding of the research process but also to teachers' deeper understanding of the learning and teaching methods and procedures which support inquiry-based approach to teaching.

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# Čimbenici povezani s učestalošću primjene istraživački usmjerene nastave Prirode i društva

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## Sažetak

*U ovome radu prikazani su rezultati istraživanja čiji je cilj bio utvrditi postoji li povezanost između učestalosti primjene istraživački usmjerene nastave Prirode i društva i stavova učitelja prema važnosti takve nastave, kao i njihova iskustvenog sudjelovanja u različitim oblicima istraživačkog učenja tijekom osobnog formalnog obrazovanja. Istraživanje je provedeno na uzorku od 275 učitelja razredne nastave Grada Zagreba i Zagrebačke županije. Rezultati su pokazali statistički značajnu razliku u procjeni važnosti istraživačke nastave Prirode i društva, učestalosti njene primjene u praksi i iskustvenih doživljaja istraživačkog učenja. Unatoč pozitivnim stavovima učitelja o istraživačkoj nastavi Prirode i društva, pokazalo se da njezino provođenje u praksi nije dovoljno učestalo, a iskustveni doživljaji istraživačkog učenja tijekom formalnog obrazovanja ispitanika uglavnom su rijetki. Uočava se kako učitelji koji pozitivnije procjenjuju važnost istraživački usmjerene nastave Prirode i društva i oni koji su imali intenzivnija iskustva istraživačkog učenja tijekom formalnog obrazovanja, učestalije organiziraju istraživački usmjerenu nastavu. Dobiveni rezultati upućuju na zaključak o važnosti oblikovanja pozitivnih stavova budućih učitelja o istraživačkoj nastavi, ali i potrebi njihova sustavnijeg uključivanja u istraživačke oblike učenja tijekom inicijalnog obrazovanja, kako bi ih na temelju tako stečenih kompetencija mogli učinkovitije i s više samopouzdanja provoditi u nastavnoj praksi.*

**Ključne riječi:** *istraživačko učenje; nastava Prirode i društva; stavovi učitelja; učestalost primjene.*