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The Role of Pedagogical Content Knowledge and Experience of Elementary School Teachers in the Implementation of Inquiry Teaching

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Abstract

The aim of the study was to assess the predictive value of pedagogical content knowledge of inquiry science and society teaching in explaining the frequency of its implementation. The sample of 320 elementary school teachers from Eastern Croatia were included in the study. Two measures were used for assessing their pedagogical content knowledge about inquiry teaching: knowledge presented in the lesson plans and self-assessed pedagogical content knowledge of inquiry teaching. The participants' experience of inquiry learning throughout their education and the frequency of its implementation in teaching science and society were assessed with the use of a questionnaire specially designed for this study. The obtained results show that the teachers' pedagogical content knowledge of inquiry teaching and their experience of inquiry learning throughout education explained 32% of the variance related to the frequency of their implementation of inquiry teaching. The same variables explained 38% of the variance regarding the implementation of inquiry activities. Additionally, the results reveal that the teachers assessed their pedagogical content knowledge of inquiry teaching as very good. Their knowledge as presented in the lesson plans was rather poor and suggested a low level of the pedagogical content knowledge of inquiry science and society teaching, indicating that the teachers are not familiar enough with the phases and activities of inquiry teaching.

Key words: *experience related to learning through inquiry; inquiry-based teaching; pedagogical content knowledge of inquiry teaching; elementary school teachers; science and society.*

Introduction

Inquiry teaching plays an important role and has a long tradition in natural sciences. It has recently gained more and more importance in teaching subjects belonging to social sciences. Research shows positive effects of inquiry teaching on: academic achievement (Chang & Mao, 1998; Ertepinar & Geban, 1996; Minner, Levy, & Century, 2010; Vitale, Romance, & Klentschy 2006), development of science skills (D'Costa & Schlueter, 2013; Ergül et al., 2011; Letina, 2013; Wu & Wu, 2011), development of positive attitudes toward science (Ergül et al., 2011; Gibson & Chase, 2002; Kyle, Bonstetter, & Gadsden, 1988; Letina, 2013; Turpin & Cage, 2004), development of understanding the ways how science works (Khishfee & Abd-El-Khlicka, 2002), and enticing students' cooperation (Wolf and Fraser, 2008). Due to the numerous positive outcomes that arise from this way of teaching, an increasing number of scientists are paying attention to investigating factors that contribute to the quality and quantity of inquiry teaching.

Teachers are recognized as the most important factor in school that directly affects the implementation of inquiry teaching because teachers are the ones who, on a daily basis, decide on different ways of how to teach and for students how to learn. While planning their teaching process, teachers conceive ways of adapting the learning contents for students. For the learning contents to find a way to students, the teacher has to know not only the subject matter (Appleton, 2008; Murphy & Smith, 2012; Nilsson & Driel, 2010; Nowicki et al., 2013; Oh & Kim, 2013; Tairab 2010), but also needs to have pedagogical content knowledge of the respective subject in order to "transform" the learning content to a form that students can apprehend (Oh & Kim, 2013). Teachers' actions are defined by the level of their pedagogical content knowledge, i.e. how successfully they can adapt the learning contents to the needs of their students. So, the pedagogical content knowledge is recognized as an important factor connected to the teaching organization and quality, and consequently, to students' progress. Research shows that the students whose teachers present a higher level of pedagogical content knowledge have better achievements because they understand the contents better, show a higher conceptual understanding and procedural knowledge, have a better terminology, understand the purpose of teaching activities better, show a higher motivation and interest, and are more efficient in transferring knowledge from other areas, compared to the students whose teachers have a lower level of pedagogical content knowledge (Baumert et al., 2010; Jones & Moreland, 2004).

For a successful preparation of inquiry teaching and its later implementation, the pedagogical content knowledge of inquiry teaching is necessary, meaning that the teacher must know what it is and how it is implemented. Teachers acquire the pedagogical content knowledge in the course of their formal teacher education. It is, however, not only the result of learning in the course of their studies because the students – future teachers – already come to the faculties of teacher education

with strong teaching-related conceptions, attitudes and beliefs based on their overall schooling experience. Their previous experience is accordingly recognized as an important factor that helps future teachers build the pedagogical content knowledge of inquiry teaching (Eick & Reed, 2002). Many authors believe that it is important for university teachers to detect their students' preconceptions and point them to contemporary learning and teaching (Brown, Friedrichsen, & Abell, 2010; Loughran, 2007; Richardson, 1996).

The way in which the teaching of future teachers was organized, i.e. how teachers were prepared in the course of formal education influences the pedagogical organization of their teaching (Wenning, 2005). If they have an opportunity to participate in inquiry teaching during their schooling, it increases their probability to work in a similar way when compared to those without such experience. This is evident especially in the case of beginner teachers because their teaching practice reflects what is familiar to them (Luera, Moyer, & Everett, 2005). The research conducted by Ibrahim (2003) shows a positive relationship between the experience of inquiry activities in the course of schooling and the teachers' subsequent teaching methods. The results show that the respondents who experienced more inquiry teaching in science not only tend to work that way more often, but also have more positive beliefs about inquiry teaching and learning. The teachers who experienced teacher-oriented science teaching more often have less positive beliefs about the importance of students' role in student-oriented inquiry teaching. As opposed to them, the teachers having more experience with student-oriented inquiry teaching are more positive regarding the importance of students' role in science teaching. These findings indicate the significance of experiencing inquiry teaching in the course of schooling because it contributes to the building of conceptions familiar to future teachers and helps them organize themselves in future. More or less experience of participating in inquiry teaching in the course of formal education, experience of implementing inquiry teaching oneself, and professional teacher training about inquiry teaching affect teachers' conceptions and beliefs about inquiry teaching and their forming of pedagogical content knowledge related to inquiry teaching, which finally contributes to becoming a traditionally or an inquiry-oriented teacher (Ibrahim, 2003).

In the course of teaching career, teachers acquire their pedagogical content knowledge that builds upon their pedagogical teaching knowledge that was acquired during the initial teacher education. Due to different teaching experiences and contexts, this knowledge is unique to every single teacher (Verloop, Van Driel, & Meijer, 2001). Clearly, the pedagogical content knowledge of inquiry teaching, as well as an adequate training during the formal teacher education play a certain role in the successful implementation of inquiry teaching (Ibrahim, 2003; Letina, 2013; National Research Council [NRC], 2000). It is, however, unknown how great the given role is. Previous research has not investigated to what extent the implementation of inquiry teaching can be predicted according to the teacher's pedagogical content knowledge

and experience. Hence, this study aims to examine the predicative value of pedagogical content knowledge of inquiry teaching and the teachers' experience during schooling in order to explain the frequency of inquiry teaching implementation in teaching science and society.

Methodology

Sample and Procedure

A total of 320 elementary school teachers participated in the study. The study was conducted in the area of Eastern Croatia including five counties: Brod-Posavina County, Požega-Slavonia County, Osijek-Baranja County, Virovitica-Podravina County and Vukovar-Syrmium County. The participants are teachers from 34 of 184 elementary schools in Eastern Croatia, 49.7% of them work in an urban school and 50.3% in a rural school (32.6% in the master rural school and 17.7% in the regional rural school). From the total number of participants, 95.9% are female and 4.1% are male. With regard to their initial teacher education, most of the teachers finished 2-year teacher education programs (43.9%), somewhat fewer respondents finished 4-year studies (42.3%), and the fewest of them graduated from a 5-year university study program (13.8%).

The sample was constructed as a cluster sample. The elementary school teacher population in Eastern Croatia is divided into clusters, i.e. professional county councils. In the first step, a list of teachers – members of the professional county councils – was drafted for each county. In the next step, the professional county councils were selected by random choice from each county to determine which councils would be surveyed. Since the councils differ in the number of teachers, in some counties the survey had to be conducted in more than one council, up to three. The number of respondents in each county was determined in proportion to the percentage of representation in the total population of elementary school teachers in Eastern Croatia. Accordingly, the greatest number of respondents comes from the Osijek-Baranja County and the smallest one is from the Požega-Slavonia County.

The research was conducted during the second term of the school year 2014/2015 by the method of teachers' self-reports according to the paper-and-pencil principle. The questionnaire was administered in groups with several professional county council teachers from the elementary education sector. After an initial address, the respondents were informed about the possibility to participate in the research guaranteeing their anonymity and about the use of collected data for the purpose of academic research. Twenty to thirty minutes were needed to fill in the questionnaire.

Instruments

Several instruments, designed for the needs of this study, were used. The respondents' socio-demographic profile was surveyed first, followed by data on their pedagogical content knowledge, implementation and experience of inquiry teaching in the course of schooling.

Pedagogical Content Knowledge of Inquiry Teaching

The data on the pedagogical content knowledge of inquiry teaching was collected using two instruments:

a) The Pedagogical content knowledge of inquiry teaching in science and society questionnaire

The questionnaire was designed for the needs of the study and consisted of one open-ended question that was quantified. This question was used to explore the procedural, pedagogical content knowledge of inquiry teaching in science and society. This paper builds on the hypothesis that a teacher capable of conceiving an inquiry teaching lesson has the procedural knowledge necessary to implement inquiry teaching in a class. Accordingly, the respondents were asked to write an inquiry teaching lesson plan for one of the offered topics from the teaching program for science and society in elementary school (grade 1 to 4). Their responses were evaluated with regard to the stated number of phases in inquiry teaching. Every phase listed was evaluated with one point. The responses with a higher number of inquiry teaching phases accordingly have a higher number of points, i.e. more pedagogical content knowledge of inquiry teaching in science and society. The phases of inquiry teaching: 1. Engaging in inquiry-oriented questions, making hypotheses; 2. Research plan; 3. Gathering data; 4. Analysis, data interpreting and drawing evidence-based conclusions; 5. Presentation of research results and discussion; 6. Evaluation of the inquiry work and learning. An inspection of the relevant world academic literature resulted in setting the number of inquiry teaching phases (Alberta Learning, 2004; NRC, 2000). The theoretical range of results lies between 1 and 7, one denoting no knowledge, i.e. not a single phase of inquiry teaching was recognized or the respondent marked having no knowledge of inquiry teaching. Seven meant that all the six phases of inquiry teaching were recognized.

b) Pedagogical content knowledge of inquiry teaching self-assessment scale

For the purpose of the study, a seven-item scale was designed exploring the pedagogical content knowledge of inquiry teaching, e.g. "I know the differences and similarities between scientific research and students' research in school". The items were based on a survey of the worldwide academic and professional reference literature, including all theoretical knowledge related to the field of inquiry teaching. The respondents assessed their level of knowledge for each item on a 5-point Likert-type scale (1- insufficient, 5 – excellent). The reliability of the scale was verified and it had a Cronbach's alpha reliability coefficient of .93, which is high given that the boundary value of the reliability coefficient in social sciences amounts to .70 (Fraenkel & Wallen, 2009; Hernon & Schwartz, 2009). The high level of reliability points to the conclusion that all items in the scale have a high mutual correspondence.

The Implementation of Inquiry Teaching

The data on the implementation of inquiry teaching in science and society was gathered using a questionnaire designed for the current study purpose. This paper

distinguishes between the implementation of inquiry teaching strategy and the use of particular inquiry teaching phases, i.e. inquiry activities. Teachers can use shorter inquiry activities, e.g. experiments, in teaching, but can also implement "real" students' inquiries lasting several days or weeks – the inquiry teaching strategy (Turner, Keiffer, & Gitchel, 2010). So, the inquiry teaching strategy implies the implementation of several inquiry activities. While designing the instrument, the first step was to theoretically determine the strategy of inquiry teaching and inquiry activities, and to subsequently determine the basic activities of inquiry teaching.

The questionnaire consisted of one item evaluating the frequency of implementing the inquiry teaching strategy and a scale evaluating the frequency of implementing inquiry activities. First, the respondents were asked to assess on a 5-point Likert-type scale how often they use the inquiry teaching strategy in science and society lessons during one school year. Following that, on a scale of 32 items, they assessed the frequency of their implementation of different inquiry activities in science and society teaching. The items, based on the relevant reference literature, define and describe inquiry teaching (e.g., NRC, 1996, 2000), and also describe the students' activities in the different phases of inquiry teaching in science and society, e.g. "The students draw conclusions based on the data collected using evidence". On a 5-point Likert-type scale, the respondents needed to assess how often they implement inquiry activities in their science and society lessons during one school year. In both scales, 1 means none (0% lessons), 2 means little (up to 10% of lessons), 3 means some (11-25% of lessons), 4 means moderate (26 to 50% of lessons) and 5 means considerable (more than 50% of lessons). The stages of the Likert scale are determined more precisely by the percentage ranges and those ranges were taken over by the study of Soldat (2009). The reliability of this sub-scale was verified and it has a Cronbach's alpha of .96.

The Experience of Inquiry Teaching in the Course of Formal Education

For the current purpose, the questionnaire *the experience of inquiry teaching through formal education* was designed to explore the respondents' experience with inquiry teaching in the course of their formal education (elementary school, high school, and faculty). The questionnaire consisted of one item assessing the frequency of experiences with the inquiry teaching strategy and a scale assessing the frequency of experiences with inquiry activities. On a 5-point Likert-type scale, the respondents first had to assess how often they had participated in the inquiry teaching strategy during their primary, secondary and tertiary education. They subsequently assessed how often they had participated in inquiry activities as elementary and secondary school students and faculty students. A 32-item scale was used to assess this including items like "The students draw conclusions based on the data collected using evidence". All the items in the questionnaire were identical to the *Implementation of inquiry teaching in science and society questionnaire.* The respondents assessed, on a 5-point

Likert-type scale, to what extent the listed inquiry activities were represented in the course of their schooling. In both scales, 1 means none (0% lessons), 2 means little (up to 10% of lessons), 3 means some (11-25% of lessons), 4 means moderate (26 to 50% of lessons) and 5 means considerable (more than 50% of lessons). The reliability of this sub-scale was verified and it has a Cronbach's alpha of .98.

Data Analysis

After the data was collected, their quantitative analysis followed by using the software package SPSS 20.0 for Windows. The descriptive characteristics of the main variables were determined like the smallest and largest value, arithmetic mean, standard deviation, skewness and kurtosis. The reliability of the given scales was verified by the measure of internal consistency Cronbach's alpha. For the purpose of exploring the predictive values of particular variables, two linear regression analyses were conducted.

Results

Table 1 shows the descriptive statistics for the variables in the focus of this study. An examination of the main study follows then.

Table 1

Descriptive indicators for the variables examined

	Minimum	Maximum	M	SD	Skewness	Kurtosis
Expressed knowledge	1	7	2.40	1.75	0.87	-0.51
Self-assessed knowledge	1	5	3.55	0.69	-0.08	0.13
Strategy implementation	1	5	3.00	0.66	-0.01	0.42
Inquiry activity implementation	1.41	5	3.45	0.66	-0.43	0.08
Strategy experience	1	5	2.38	0.71	0.21	0.45
Inquiry activities experience	1	5	2.89	0.80	-0.13	-0.17

Note. M – arithmetic mean; SD –standard deviation

The predictor variables were slightly asymmetrically distributed (either to the left or to the right) and in accordance with the values of the arithmetic means (the scale direction). In terms of kurtosis, the variables ranged from being slightly platykurtic to being moderately leptokurtic, which is in accordance with the data variability. Since these are composite variables, the variability coefficient does not follow the kurtosis trend with regard to certain predictor variables, hence caution is advised with generalizations.

Given that average variable scores are evaluated and expressed in decimals, the theoretical score values on the 5-point Likert scale are interpreted as follows: a score above 1 up to 1.49 denotes 1, a score above 1.5 up to 2.49 denotes 2, a score above 2.5 up to 3.49 denotes 3, a score above 3.5 up to 4.49 denotes 4 and a score above 4.5 denotes 5. The theoretical score values in the lesson plan range from 1 to 7, hence the

decimal values are interpreted as follows: a score from 1 to 1.49 signifies *no knowledge*, a score from 1.5 to 3.49 signifies a *low level of knowledge*, a score above 3.5 to 4.49 signifies a *medium level of knowledge* and a score above 4.5 to 7 signifies a *high level of knowledge*.

The level of pedagogical content knowledge was determined using a composite variable of self-assessed knowledge consisting of seven items and the variable of expressed knowledge (lesson plan). The descriptive data show that on average teachers tend to assess their pedagogical content knowledge of inquiry teaching as very good. However, their real expressed knowledge in the lesson plans indicates a low level of knowledge. The results show that on average only one phase of inquiry teaching was recognized in the lesson plans (M=2.40) with a scatter among the respondents of almost two phases (SD=1.75). On the other hand, it is necessary to note that there is no precise attitude about the number of inquiry teaching phases in the academic reference literature, which is why the current score should be interpreted with caution.

The level of inquiry teaching implementation was determined using the variable *strategy implementation* and the composite variable *inquiry activity implementation* consisting of 32 items. According to the arithmetic means, as shown in Table 1, the teachers mostly implement the strategy of inquiry teaching and sometimes apply inquiry activities. Still, inquiry activities are implemented slightly more frequently than the strategy.

After assessing the implementation of inquiry teaching, the teachers again had to assess the same items in terms of the frequency of experiencing the inquiry teaching strategy and inquiry activities in the course of their formal education (elementary school, high school, and faculty). So, the level of experience with inquiry teaching was determined using the variable *experience of inquiry teaching strategy* and the composite variable *experience of inquiry activities* consisting of 32 items. The results show that the experience with inquiry teaching strategy was rare for the most part, while there is slightly more experience with inquiry activities that were mostly implemented sometimes (Table 1).

In order to examine the predictive contribution of pedagogical content knowledge and inquiry teaching experience to the implementation of inquiry teaching, two linear regression analyses were conducted. In both of them, the independent variables are expressed knowledge, self-assessed knowledge, strategy experience and inquiry activity experience. In the first regression analysis, the criterion variable was the implementation of inquiry teaching strategy (Table 2) and, in the second one, the implementation of inquiry activities (Table 3).

The Relationship between the Pedagogical Content Knowledge and Inquiry Teaching Experience and the Implementation of Inquiry Teaching Strategy

First, the assumptions for the use of regression analysis were tested. The assumption of linearity was given, outliers were checked, autocorrelation was not confirmed

(Durbin-Watson), and neither was multicollinearity as a variance inflation factor (VIF) on individual predictor variables. In addition, the ratio of predictor variables and N was satisfactory (Evans' rule).

The results of the first regression analysis show that 32% of the variance in the implementation of inquiry teaching strategy can be explained with the self-assessments of pedagogical content knowledge and the self-assessments of experience with inquiry teaching (Table 2). Of the four predictors included, only the self-assessed knowledge and the strategy experience proved statistically significant (Table 2).

Table 2

Coefficients of linear regression analysis for the variable implementation of inquiry teaching strategy

	b	S.E.	β	t	p
Expressed knowledge	0.025	0.019	0.063	1.325	0.186
Self-assessed knowledge	0.350	0.047	0.363	7.408	0.000
Strategy experience	0.364	0.050	0.385	7.344	0.000
Inquiry activities experience	-0.063	0.043	-0.075	-1.461	0.145

R=0.579; R^2=0.336; Adjusted R^2=0.327; Durbin Watson=2.042

The Relationship between the Pedagogical Content Knowledge and Inquiry Teaching Experience and the Implementation of Inquiry Activities

As with the previous analysis, the second regression equation also met all assumptions for the use of regression analysis. The results show that, by expressed knowledge, self-assessed knowledge, strategy experience and inquiry activities experience, 38% of the variance *implementation of inquiry activities* (Table 3) can be explained. Of the four predictors included, three proved statistically significant, with self-assessed knowledge having the highest predictive value (Table 3).

Table 3

Coefficients of linear regression analysis for the variable implementation of inquiry activities

	b	S.E.	β	t	p
Expressed knowledge	0.036	0.017	0.094	2.050	0.041
Self-assessed knowledge	0.466	0.044	0.499	10.582	0.000
Strategy experience	-0.014	0.046	-0.015	-0.301	0.764
Inquiry activities experience	0.259	0.040	0.318	6.449	0.000

R=0.623; R^2=0.389; Adjusted R^2=0.380; Durbin Watson=1.968;

Discussion

Before we can proceed to the discussion about the main aim of the current study, it is necessary to discuss the scores of the average values of variables that are in the focus here.

In this study, the pedagogical content knowledge was evaluated using objective (lesson plan) and subjective measures (self-assessment). The evaluation of pedagogical content knowledge as expressed in the lesson plan builds on the assumption that a teacher, who is capable of conceiving a lesson plan for inquiry teaching, is also capable of implementing it in class. But before this result is interpreted, it is important to remark and discuss several important points. First of all, a teacher's true knowledge of inquiry teaching is much broader than it can be expressed in a lesson plan. The pedagogical content knowledge cannot be subjected to direct assessment, which is why the lesson plans in this study express how well a teacher knows the phases and basic activities of inquiry teaching. Hence, the respondents have shown the expressed knowledge in limited time, at a specific moment, and on a certain example (Kagan, 1990; Rohaan, Taconis, & Jochems, 2009). Secondly, it is important to discuss the criterion for evaluating the pedagogical content knowledge in the lesson plans, which were the phases, i.e. the description of activities in particular phases. The criterion selected here is in accordance with the world relevant academic and professional literature; however, there is no reference to this in the Croatian professional literature on teaching science and society in elementary school, just as it was not translated into the Croatian language. It can be assumed that most teachers interviewed here use literature that can be accessed in Croatia and is meant for elementary school teachers, i.e. books and articles that are either translated or written in the Croatian language. According to that, it needs to be clarified why the criterion was not based on the accessible literature. De Zan's *Pedagogical content knowledge of science and society* (1994, 2005) has been the basic textbook for science and society teaching courses at faculties for years. De Zan's model of inquiry-centered teaching contains very similarly entitled and described inquiry activities as the phases that were evaluated in the lesson plans. However, his model also incorporates the traditional phases of the teaching process (like exercises and revisions of the acquired knowledge, etc.), while the criterion chosen here was meant to be in accordance with the contemporary model of inquiry teaching. As in other accessible Croatian texts on didactics and the relevant pedagogical content knowledge, intended for elementary school teachers and science and society teaching, there inquiry teaching is depicted only very briefly or it is not depicted in accordance with contemporary views. The third point that must be mentioned is that, in the world academic literature, there is no precise attitude about the number of phases in inquiry teaching because that depends on the topic and purpose of specific students' research. There is, however, a certain consensus. Disagreement about the number of phases would differ in two stages at most. Considering the afore-mentioned, the result of expressed knowledge in the lesson plans should be interpreted with caution.

The results of the questionnaire testing the pedagogical content knowledge of inquiry teaching, based on the lesson plans, show that on average only one phase of inquiry teaching was recognized. Taking into account all of the afore-mentioned, the expressed knowledge is very low. Multiple reasons can be stated to explain the result. First of all, the low level of knowledge shows that the teachers were insufficiently

capacitated during formal and informal teacher education with regard to the relevant pedagogical content knowledge that is needed to organize and implement inquiry teaching. Other studies conducted in Croatia have supported the fact that teachers are not capacitated enough. For example, a large-scale questionnaire survey conducted on a sample of over 8.000 teachers showed that teachers expressed a dire need for professional training and improvement in encouraging the development of autonomous learning in students and enabling a learning process based on problem solving, critical understanding, analysis and creativity (Roeders, 2013). These two competencies were estimated as needed the most among a total of 50 professional competencies listed. Similarly, a study conducted in the Sisak-Moslavina County shows that from 17 professional competencies listed teachers estimate themselves the least qualified for the implementation of project and inquiry teaching (Basta & Zuber, 2014). Aside from the results of the studies conducted, the low level of pedagogical content knowledge could have been expected given that inquiry teaching is poorly represented in the professional literature for elementary school teachers in Croatia. Many publications mention inquiry teaching as one method of work without giving more precise directions for teaching, or it is even depicted in a way that is not in accordance with the contemporary views of students' research. Teachers in Croatia are no exception, for studies across the world also confirm that teachers lack the pedagogical content knowledge. The studies of Espinosa-Bueno, Labastida-Pina, Padilla-Martinez, and Garritz (2011), Ireland (2011), Schneider and Plasman (2011), to name just some, show that teachers are not sufficiently familiar with inquiry teaching, and also that their pedagogical content knowledge differs greatly with regard to the relevant literature. However, it is also possible that the result uncovering a low level of pedagogical content knowledge could have been caused by fatigue and a lack of motivation of the teachers to fill in the lesson plans. It should be taken into account that the data was collected in the meetings of the professional county councils which mostly took place in the afternoon when the teachers had finished classes. Conceiving a lesson plan requires mental engagement, so it is possible that the teachers were not engaged enough when filling in the lesson plan because they were tired and unmotivated after a day's work.

The subjective assessment results show that the teachers deem their level of pedagogical content knowledge of inquiry teaching as *very good*. However, while interpreting the self-assessed knowledge results, the respondents' subjectivity should be considered as well as their tendency to answer with higher scores. It is hard to imagine a teacher indicating no knowledge of inquiry teaching since that topic was surely covered in the course of their teacher education. The teachers were assessed according to their knowledge and the results show that they believe to have a very good level of inquiry teaching knowledge.

The results related to the inquiry teaching implementation show that most of the teachers sometimes implement the inquiry teaching strategy and research activities.

This amounts to 11 to 25% of the total time for science and society teaching in the course of one school year. Research and inquiry-based activities are, however, applied somewhat more often. They mostly had little experience with the inquiry teaching strategy in the course of their formal education. Up to 10% of teaching was organized this way, while the experience with inquiry activities was slightly more frequent. Considering that the implementation of inquiry teaching strategy is more complex and requires a greater time effort, it is not surprising that the strategy is implemented less often compared to inquiry activities, but also that the teachers implement it less often than inquiry activities.

The main aim of the study was to examine the predictive value of the pedagogical content knowledge of inquiry teaching and that of the teachers' experience in the course of education to explain the frequency of the implementation of inquiry teaching in science and society. Since this paper clearly differentiates between the implementation of inquiry teaching strategy and the use of specific elements of inquiry teaching, i.e. inquiry activities, two linear regression analyses were conducted for each construct as a criterion.

The results show that approximately 32% of the variance in strategy implementation can be explained with the assessments of pedagogical content knowledge and the assessments of experience with inquiry teaching in the course of schooling. The frequency of the implementation of inquiry teaching strategy is independently predicted by the self-assessed knowledge and the assessment of the experience with strategy, while the actual pedagogical content expressed knowledge in the lesson plan and the assessment of the experience with research activities are not predictive. It can be assumed that the reasons for that are also certain limitations of the criterion variable *strategy implementation* and the predictor variables *self-assessed knowledge* and *strategy experience*. While assessing the pedagogical content knowledge, every teacher had a personal conception of what inquiry teaching is and it was based on this knowledge. Starting from that, the teachers assessed different aspects of their inquiry teaching knowledge. At the same time, the teachers were to assess how often they implement the inquiry teaching strategy in the course of one school year and to what extent the teaching during their formal education was organized that way. The questionnaire did not provide a precise explanation of inquiry teaching strategy because the same questionnaire examined the objective evaluation of pedagogical content knowledge expressed in a lesson plan. Hence, the teachers did the assessments according to their knowledge of inquiry teaching. Every teacher used their own parameters for inquiry teaching, i.e. their own criterion. This is reinforced by the result that the prediction of the strategy implementation cannot be based on the knowledge expressed in the lesson plans, but only on the self-assessed knowledge and the assessment of experience with the strategy when the teachers were assessed taking into account the same criterion.

With regard to the implementation of inquiry teaching strategy, the results of the second regression analysis are somewhat clearer. While assessing the implementation of

inquiry activities, the activities were precisely listed so the teachers had approximately the same conceptions. The results show that approximately 38% of the variance in the implementation of inquiry activities can be explained with the assessment of pedagogical content knowledge and the assessments of experience with inquiry teaching in the course of schooling. Only strategy experience does not independently predict the implementation of inquiry activities. It can be assumed that the reason is the afore-mentioned limitation of this variable.

It is not possible to compare the current results with the results of other studies because, to the authors' knowledge, other studies did not examine those in this manner. Research of the same issues, but applying different methodology, has showed that the pedagogical content knowledge of teachers is strongly related to teaching practice, i.e. the way in which teachers organize their lessons and teaching. The study of Park, Jang, Chen, and Jung (2011) shows that teachers with a higher level of the pedagogical content knowledge (knowledge about the students' understanding of teaching contents and knowledge of teaching strategies and representations) implement inquiry-based and student-centered teaching more often. The experimental research by Diaconu, Radigan, Suskavcevic, and Nichol (2012) examined the efficacy of the professional improvement program teachers used to enhance their knowledge of science and their pedagogical content knowledge of constructivist learning and inquiry-oriented teaching. The results showed that, with the increase in knowledge, the teaching practice changed, i.e. the implementation of inquiry-based teaching. Similarly, research on the experience in the course of formal schooling confirmed the relationship between the teachers' teaching practice and the kind of teaching they had observed and experienced. The study of Ibrahim (2003) showed that the respondents who had more experience with inquiry teaching in science not only worked that way themselves more often, but also had more positive beliefs about inquiry teaching and inquiry-based learning.

Both regression analyses showed that approximately 65% of the variance remained unexplained. Considering that numerous previously conducted studies have shown the great importance of pedagogical content knowledge and experience with the implementation of inquiry teaching, it is necessary to discuss why so much of variance remained unexplained. It is assumed that one of the reasons lies in the complexity of the relationship between the pedagogical content knowledge, experience and implementation of inquiry teaching. The fact that approximately 65% of the variance remained unexplained actually indicates the complexity of the factors that affect the implementation of inquiry teaching. Aside from the pedagogical content knowledge and experience during schooling, research confirms that there are numerous factors influencing the quality and quantity of the inquiry teaching implementation, such as the teachers' knowledge of learning contents (Alonzo, 2002; Petish & Davis, 2001; Sanders, Borko, & Locard, 1993) and knowledge of science practice (NRC, 2000).

Besides requiring knowledge of different fields, the implementation of inquiry teaching clearly confronts teachers with many difficulties and challenges that need to be overcome (Costenson & Lawson, 1986). That is why there are multiple factors affecting the implementation of inquiry teaching, and any simplification of the relationships can lead to wrong conclusions.

Likewise, the results of this study need to be viewed in the context of the research outline, especially the way the variables were evaluated. All variables in this study, except for the expressed knowledge in the lesson plan, are based on self-assessment. Respondents' self-assessments contain a certain amount of subjectivity. The respondents used their own parameters that are influenced by personal implicit standards (Moè, Pazzaglia, & Ronconi, 2010), so there are no exact indicators. Furthermore, self-assessments hold within the tendency for socially desirable responding. Since inquiry teaching is considered a synonym for quality science and society teaching by admitting to not having enough knowledge and not implementing inquiry teaching, respondents would be presenting themselves in a bad light. Hence, with self-assessments there is the tendency of responding with higher, socially desirable scores. While the previous experience of teachers during schooling could not be assessed otherwise, in future studies the assessments of pedagogical content knowledge and of the implementation of inquiry teaching should certainly be directed toward more objective measures, i.e. a different methodology and the elimination of the afore-mentioned limitations of this study.

The practical implications of this study primarily refer to the fact that the teachers showed a very low level of the pedagogical content knowledge of inquiry teaching. Everyone engaged in the education of future teachers, for the most part responsible for the existing situation, being mainly the faculties of teacher education, should be made aware of the fact. This does not relate only to those in charge of teaching the pedagogical content knowledge of science and society but also to those who are in charge of courses dealing with the science- and society-related contents since their students will later teach them to their students. It is not enough that students only have the knowledge of inquiry teaching and are vaguely familiar with it. They need to have the possibilities of experiencing such teaching by their university teachers, teaching where students conduct research, which does not mean that any teaching at the university level should be organized in this way, as that would be impossible. However, students should have the possibility to conduct research at least two or three times in the course of their formal teacher education. Likewise, within the study course, the pedagogical content knowledge of science and society students should be encouraged and they should be given maximum professional support when planning inquiry teaching for the lessons of science and society they perform in schools during studies. In schools, where they exercise teaching, students are trained in the ways of organizing their future teaching process, which is why it is important that the inquiry teaching strategy becomes a well-known way of teaching science and society.

Conclusion

The current study showed that approximately 32% of the variance in the strategy implementation could be explained by two predictor variables, *pedagogical content knowledge* and *experience with inquiry teaching during schooling*, while the same predictor variables explain approximately 38% of the variance with regard to the *inquiry activity implementation*. Therefore, approximately 65% of the variance in the inquiry strategy implementation remained unexplained. The results also indicated a very low level of pedagogical content knowledge when it came to the inquiry teaching of science and society showing that teachers lack adequate competencies in the pedagogical content knowledge that are needed to organize inquiry teaching in their teaching practice.

Finally, it should be emphasized that the relationship between pedagogical content knowledge, experience during schooling and implementation of inquiry teaching is an extremely complex one, influenced by numerous, but also interactive factors. It was not possible to include all factors affecting the implementation of inquiry teaching in one study. The discussion indicated some methodological limitations of certain variables, so future studies should by all means use a different methodology trying to overcome the limitations of this study.

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Uloga metodičkog znanja i iskustva učitelja u provedbi istraživačke nastave

Sažetak

Cilj je ovog istraživanja ispitati prediktivnu vrijednost metodičkog znanja o istraživačkoj nastavi i iskustva učitelja tijekom školovanja za objašnjenje učestalosti provedbe istraživačke nastave u Prirodi i društvu. U istraživanju je sudjelovalo 320 učitelja primarnog obrazovanja s područja istočne Hrvatske, a uzorak je sastavljen kao uzorak klastera. Razina metodičkog znanja učitelja o istraživačkoj nastavi procjenjivana je na temelju dviju procjena: nastavnih priprema i samoprocjene metodičkog znanja o istraživačkoj nastavi. Iskustva istraživačke nastave tijekom školovanja i učestalost njezine provedbe u Prirodi i društvu procjenjivani su na temelju upitnika koji su konstruirani za potrebe ovog istraživanja. Rezultati su pokazali da se 32 % varijance provedbe strategije može objasniti procjenama metodičkog znanja i procjenama iskustva u istraživačkoj nastavi tijekom školovanja, a da iste prediktorske varijable objašnjavaju 38 % varijance primjene istraživačkih aktivnosti. Ovo je istraživanje pokazalo da učitelji smatraju da je razina njihova metodičkog znanja o istraživačkoj nastavi vrlo dobra, a da rezultati znanja iskazanoga u nastavnoj pripremi zapravo pokazuju da učitelji imaju vrlo nisku razinu metodičkog znanja o istraživačkoj nastavi Prirode i društva, odnosno da nedovoljno poznaju etape i temeljne aktivnosti istraživačke nastave.

Ključne riječi: *iskustvo istraživačke nastave; istraživačke aktivnosti; metodičko znanje o istraživačkoj nastavi; Priroda i društvo; učitelji razredne nastave.*