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IDENTIFICATION OF MATHEMATICS' TEACHERS BELIEFS CONNECTED TO INQUIRY-BASED LEARNING

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ABSTRACT. *Teachers are considered as one of most important factors concerning implementation of innovation in education, including inquiry-based learning. From the research in this area we consider beliefs and knowledge for teaching mathematics as the biggest influence on teachers' decisions making in practice. So that is why beliefs and knowledge of teachers are crucial inputs to courses of professional development. In our contribution we design the theoretical framework for analysis of teacher beliefs. Tool for characterizing teachers based on their beliefs is described and its use is illustrated on case of Beata who participated in course of professional development.*

KEY WORDS: *teachers' beliefs, in-service teachers, professional development*

CLASSIFICATION: *D504*

Introduction

Even teaching is considered as a social activity, the teacher is the main decision-making person in the classroom. Approximately every two minutes teacher has to take important decisions in order to solve various kinds of problems (related to students' knowledge, classroom management, etc.) (Handal & Herrington, 2003). According to Schoenfeld (2011), in order to attempt the process of solving problems (not only in mathematics) and understand it, it is necessary to examine person's knowledge base, repository of problem-solving strategies, means of monitoring and self-regulation (metacognitive skills) and his/her beliefs.

Variety of educational research examined the relation between teachers' beliefs and their institutional practice (Handal, 2003). Ernest (1989) suggested that beliefs are the primary regulators for teachers' acting and practice in classroom. Furthermore, they claim that without change in teachers' beliefs the change in school-practice is not possible (Chapman, 1999). However, the change in affective level is longitunidal process and to be successful in it, teacher has to obtain several good cases and examples of good-practices within the innovation in education (Čeretková/PRIMAS, 2011). Hermans et al. (2008) suggest that there is a shared set of educational beliefs in particular schools. This is in conclusion with Pajares (1992) who reported about sharing common beliefs within supportive groups which teachers tend to form to gain confidence. Paris and Combs (2006) propose that this kind of sharing of teaching practices depend on the school culture.

One of main objectives of 7FP project PRIMAS (Promoting Inquiry in Mathematics and Science across Europe) was to "support teachers with inquiry-based learning (IBL) pedagogies in mathematics and science". According to project's materials (Čeretková/PRIMAS, 2011), in a narrow sense, IBL may be defined as a teaching approach which intends to promote learning by engaging students in any of the processes or activities typically involved in scientific research. Within the project the broader understanding what IBL means is used. It includes activity and independent work of

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students, role of teacher as a facilitator of students' learning, collaborative classroom atmosphere and processes and competences as a part of expected learning outcomes. In promoting IBL to teachers' community local contextual factors (e. g. national curriculum, national assessment, textbooks, opinions of students and their parents) have to be taken into account (Dorier/PRIMAS, 2012). Contextual factors defined in Dorier/PRIMAS (2011) can be evaluated on the national level and taken into account when planning the courses for professional development (CPD) of mathematics teachers. CPDs were chosen as a main tool to spread the IBL into regular mathematics education. On the other side, the characteristics of the teachers participating of CPD and their tendency to adopt IBL have to be investigated individually.

The study

As Handal & Herrington (2008) claim: "Teachers are those who ultimately decide the fate of any educational enterprise. Consequently…discrepancies between teachers' opinions and ideas underpinning a curriculum innovation need to be identified, analyzed and addressed." Individual characteristics of teachers participating on CPD about IBL are needed in order to adopt the structure of CPD and course materials for needs of the group and to choose the right intervention for each participant. With this intention we tried to develop a framework for such kind of identification. On the other hand it is useful for better understanding of the mathematical background of Slovak mathematics teachers.

We assumed that the information of teachers' knowledge and teachers' beliefs will be the most crucial aspects for positive implementation of IBL in their classrooms. In this paper we focused on three different types of mathematics teachers' beliefs and consider their possible influence to willingness of teachers to implement IBL in their day-to-day teaching. From the wide variety of areas we narrow ourselves to: mathematics that the teacher consider as the most important in the classroom, the goal that this mathematics have in the classroom and the instructions that are needed to achieve valuable outcomes.

Beliefs about mathematics

The first area Liljedahl (2008) describes three possible concepts of mathematics and their influence on acting in classroom: (a) **Mathematics as toolbox** – means that mathematics is seen as a set of rules, formulas, skills and procedure, therefore these are stressed by the teacher and memorization and mastery are enforces. Mathematics activity is understood as calculating, using rules, procedures and formulas. (b) **Mathematics as system** – in this aspect mathematics is characterized by logic, rigorous proofs and exact definitions with precise mathematical language. Proofs and definitions are used not only as content, by also as pedagogical strategies. Doing mathematics activity means to develop accurate proofs using precise language. (c) **Mathematics as process** – the main aim of the teacher understanding mathematics as process is to provide students with experience with the doing of mathematics. Relations between different notions play important role. Mathematics activity in this case means generating rules and formulas, inventing or re-inventing mathematics.

Beliefs about teaching goals

The second area that we consider as crucial in teacher beliefs system is connected with contribution made by Kuhs & Ball (1986; in Pepin, 1999) which identified four distinct approaches to teaching mathematics: (a) **Learner-focused** – teaching is focused on

students' inquiry and development; (b) **Content-focused with emphasis to conceptual understanding** – teaching is led by content, but conceptual understanding is stressed; (c) **Content-focused with emphasis to performance** – high performance and mastery of students is the main goal; (d) **Classroom-focused** – teaching is based on good knowledge about effective classroom.

Beliefs about mathematics instruction

The third part that we choose was defined by Murphy et al. (2004) which distinguishes two main characteristics of instruction in mathematics classroom. (a) **Teacher-centered** means mostly lecturing with classroom discussion. (b) **Student-centered** means involving classroom practices that actively engage students in activities that can assist them to construct mathematical concept, require reasoning and creativity, applying information etc.

Methodology

Looking for approach how to identify teachers' beliefs we agree that it is hard to be scientific about human affairs in comparison to objectivity of nature (Bunge, 1996). Particularly, beliefs are hidden structures underpinning subjects' behavior, opinions and decision-making, therefore they have to be studied in indirect way. Constructivism was chosen as an inquiry paradigm.

The research question was:

- How can be teachers' beliefs identified congruent with their classroom practice?
- How are these beliefs influenced by school culture?

According to previous analysis of national contextual factors (Dorier/PRIMAS, 2012), we expect Slovak teachers to have concept of mathematics as a system due to the way how are future teachers educated at the university in Slovakia. Based on nature of national assessments we assume the teachers to be content-oriented with emphasis on performance. As it is only few years since the curricular reform and lack of opportunities to practice, we suppose that the teachers will use mostly teacher-centered instruction.

Several sources of data were analyzed. Teachers were **interviewed** by semi-structured interview aimed to obtain information about their beliefs about mathematic and their teaching. Sample **lesson** for each teacher was **video-taped** to investigate their classroom practice. The **whole-group** discussion was performed to obtain information about the teachers' opinions what does good teaching of mathematics mean.

Implementation

In order to evaluate designed theoretical frame we piloted it at CPD about IBL in upper-secondary mathematics organized within the project PRIMAS. We choose one teacher, using pseudonym Beata, from grammar school that has strong tradition in students performing high in assessments and in mathematics competitions. Teaching in mathematics is mostly uniformed and teachers teaching in the same grade use the same curriculum maps, so they may use the same assessment forms. Teachers usually do not discuss their pedagogies, but they share developed tasks or other classroom materials.

Beata is a teacher with three years of teaching experience. As she mentioned, she is teaching in traditional organization of lesson. At the beginning she explains the theory,

then she shows it on few examples and then practice the topic together on several tasks. We consider her teaching beliefs about mathematics instruction as teacher-centered.

Beata characterized a good math teacher as: "Somebody, that knows mathematics well, at least at the higher level than he teaches." Except it he must be able to explain the content in several ways and adapt it also to the low-achieving students. As a third main condition she mentioned that good teacher needs to be empathetic and able to work with young people, to understand them and to be tolerant. It is evidence that she sees teaching within its social environment and put strong emphases on teacher mathematical content knowledge. We can connect it to the model of teacher knowledge that was presented by Ball et al. (2008). In that model authors elaborated the two main categories of teachers' knowledge running on Shulman (1986) who characterized teachers' knowledge as pedagogical content knowledge and subject content knowledge, in our case mathematical content knowledge. If we analyze it more deeply, then Beata pointed to common content knowledge CCK – as a mathematics that the teacher needs to know at least at the one level higher to pass his students' needs. The other key factor was the specialized content knowledge SCK that she sees as something crucial for teaching mathematics. When she was interviewed about outcomes of her teaching and her beliefs about learning she mentioned that she "wanted her students to understand what they have learned". And when we turned the question to teaching she characterized it as: "leading students to use logical thinking and constructive thinking" and this can be done in all mathematics topics. This is in contradiction with the classroom practice where she spends a lot of time on practicing and drills the algorithms and formulas that are required for tests and final assessment. When she was asked how she defined a good learning and teaching Beata had difficulties to formulate the answer. It is something that she has not questioned by herself in more detail. It may be caused by lack of reflection on her pedagogical content knowledge, or some level of uniformity in teaching at her school might cause that she is not questioning in her teaching, or she may not be aware of different approaches she is using. Her teaching goals are hidden into the common regular practice that she experienced as a student, at the university and now as a mathematics teacher.

Generally, she mostly focused on the content. If we focused our attention to beliefs of inquiry-based learning she was positive about it and willing to using it, but the main contextual factor that is hindering her in the classroom is the lack of time.

Using descripted theoretical framework we would characterize Beata as **teacher-centered** teacher (Murphy et al., 2004) and she is **content-focused with emphasis to performance** (Kuhs & Ball, 1986) but she claims she would like to teach her students to think, but she does not know how. This may indicate the internal tendency to emphasize the conceptual understanding. In the relation to concept of mathematics (Liljedahl, 1999), Beata emphasized practicing, memorizing and knowledge of formulas. This implies her understanding **mathematics as toolbox**. However, in her personal beliefs she is set more in concept of **mathematics as process**. She would like to stress relations between the mathematical objects, role of metacognition, but she does not use this in her teaching.

If we look at it from the perspective of the content, there is discrepancy between her actual beliefs and practice. She wanted her students to develop important process skills that they will need in their future career but in the classroom she is using mostly mathematics as a tool.

Discussion

From the presented theoretical framework we consider that teachers understanding mathematics as a process are the most tending to use constructivist pedagogies, inquiry-based learning included. We assume that the teachers with concept of mathematics as a system can also successfully implement IBL, but in other topics than teachers with mathematics as process. Based on the analysis we would like to focus Beata's attention to the discrepancy between her beliefs and classroom practice. This may cause the willingness of Beata to use classroom practices within her not enacted process beliefs.

Active role of student is typical for inquiry-based learning, so teachers whose beliefs about mathematics instruction are student-centered are more likely to use IBL in their practice. In the case of Beata and her teacher-centered beliefs we need to identify the biggest source of contribution to these beliefs. We assume it may be the strong influence of previous practice as a student as well as the strong school culture that is mostly teacher-oriented. For accurate consideration more data are needed. Within these settings we need to start questioning the school culture, teacher practice as well as looking and reflect at different IBL processes that may occur also in teacher-centered classroom.

From characteristics of approaches it is obvious, that teachers with learner-focused goals of teaching are the most willing to use inquiry-based learning. Teachers with classroom-focused teaching goals may also tend to adopt IBL, as one of its characteristics is collaborative classroom culture. Our assumption is that the most reluctant to IBL will be teachers emphasizing the performance of the students, because classroom activities within IBL are considered to more time-consuming and there will be less time for memorizing and drill of some skills or algorithms. This can lead to teachers' assumptions that their students will score less of national assessment.

As we assumed, from observing the teaching practice and from the interview with the teacher, we categorized Beata beliefs consistently with initial assumptions. But from the interview we identify a tension between her current and ideal practice. We see the main reason of this tension in the school culture oriented to performance and in the lack of experience in students-oriented classroom activities.

As a consequence for CPD we think that experience and reflection on activity involving students' inquiry planned in detail can be helpful to persuade the teacher about the advantages of implementing IBL into her day-to-day teaching. Designed framework may serve as a tool for analysis that seems to be reasonable way to structure the interview with participants of the CPDs about IBL. It was useful not only to evaluate current beliefs and practice, but also identify the sources of tension between real and ideal practice.

References

[1] Ball, D.L., et al. (2008) Content knowledge for teaching. What makes it special? In *Journal of Teacher Education*. 2008(59). 5, pp. 389-407.

[2] Bunge, M. (1996). Finding Phylosophy in Social Science. YALE University Press, 1996. 432 p.

[3] Čeretková, S./PRIMAS (2011*). Guide of supporting actions for teachers in promoting IBL*. Available at http://www.primas-project.eu

[4] Chapman, O. (1999). Inservice teacher development in mathematical problem solving. In *Journal of Mathematics Teacher Education.* 1999(2). 2, pp. 121-142.

[5] Dorier, J.L./PRIMAS (2012). *PRIMAS context analysis for the implementation of IBL: international synthesis report*. Available at http://www.primas-project.eu

[6] Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: a model. In *Journal of Education for teaching: International research and pedagogy*. 1989(15).1, pp. 13-33.

[7] Handal, B. (2003). Teachers' mathematical beliefs: A review. In *The Mathematics Educator*. 2003 (13). No. 2, pp. 47-58.

[8] Handal, B., Herrington, A. (2003). Mathematics teachers' beliefs and curriculum reform. In *Mathematics Education Research Journal*. 2003(15), 1, pp. 59-69.

[9] Hermans, R. et al. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. In *Computers & Education*. 2008 (51), pp. 1499-1509.

[10] Kuhs, T.M. and Ball, D.L. (1986) *Approaches to teaching mathematics: Mapping the domains of knowledge, skills, and dispositions.* East Lansing: Michigan State University, Center on Teacher Education.

[11] Liljedahl, P. (2008). Teachers' beliefs as teachers' knowledge. *In Symposium on the Occasion of the 100th Anniversary of ICMI* (Rome, 5-8 March 2008).

[12] Munby, H. (1982). The place of teachers' beliefs in research on teacher thinking and decision making, and an alternative methodology. In *Instructional Science*. 1982(11). 3, pp. 201-225

[13] Murphy, K. et al. (2004). The good teacher and good teaching: comparing beliefs of second-grade students, preservice teachers, and inservice teachers. In *The Journal of Experimental Education*. 2004(72), Iss. 2, pp. 69-92.

[14] Pajares, M.F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. In *Review of Educational Research*. 1992(62), pp. 307-332.

[15] Paris, C., Combs, B. (2006). Lived meanings. What teachers mean when they say they are learner-centered. In *Teachers and Teaching: theory and practice*. 2006(12). 5, pp. 571-592.

[16] Pepin, B. 1999. Epistemologies, beliefs and conceptions of mathematics teaching and learning: the theory, and what is manifested in mathematics teachers' work in England, France and Germany. In *Behind the Rhetoric, the Realities of Teacher Education* (Lisbon, May 28-31 1999).

[17] Shulman, L.S. (1986). Those who understand: knowledge growth in teaching. In *Educational Researcher*(15), 2, pp. 4-14.

[18] Shoenfeld, A.H. (2011). *How We Think. A theory of goal-oriented decision making and its educational application.* New York, NY: Routledge, 2003. 194 p.

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