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DEVELOPMENT OF QUESTIONING IN INQUIRY–BASED PEDAGOGY – PILOT STUDY

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Abstract

In our contribution, we analyse the possibilities for professional development within several seminars which were taught using an IBL material. We focus on the way the material was taught to the prospective teachers of mathematics during the course Methods of Solving Mathematical Problems. We orientate ourselves on the identification of different levels of questioning during the seminar. In the discussion, we suggest the possibilities of using these findings in the process of better understanding of IBL into the specific educational culture (settings) that will serve in the process of CPD courses development.

1 Introduction

Mathematics education in Slovakia goes through several changes that are driven from inner but also from outside needs. International comparative studies are one of the main outside factors. For example, an international comparative study OECD PISA 2003 was focused on mathematical literacy and Slovakia was not significantly different from the OECD average. From that time Slovak mathematics performance has not significantly changed (Koršňáková et al., 2009). On the other hand, the biggest inside change was the school reform in 2008. This reform offers more freedom for schools in preparing their school educational programme. This possibility enables the usage of innovative methods, such as Inquiry-Based Learning (IBL). For teachers, these are often new approaches and, therefore, a possible ways of their implementation need to be investigated.

Dealing with the problem of IBL implementation in the classroom, it is necessary to look at the problem more holistically. There are several aspects that need to be considered, for instance the lack of experience of students and also prospective teachers and in-service teachers with IBL pedagogy. This experience can be partly substituted by familiarising with other ways of teaching and learning during prospective teacher education.

In mathematics, the notion of Problem-Based Learning (PBL) is used more often than IBL. It emerges from the reality that most mathematical activities are done through solving problems. The implementation of this situation can cause several problems on the side of students but also on the side of teacher. In our study, we are closely concerned with the latter where we look at the usage of IBL material during University course “Methods of Solving Mathematical Problems”.

Our aim was to better understand the way how the teacher educator would present and organise classroom settings for prospective teachers based on the questions she asked and how her reflection influenced her way of teaching on the parallel seminar. The activity was done within the project PRIMAS. PRIMAS is the acronym of the European project *Promoting Inquiry in Mathematics and Science Education across Europe* within the Seventh Framework Programme which has received funding from the European Union. The main aim of the project is the implementation of inquiry-based learning of mathematics and science into every-day teaching. The project partners develop resources for 6-16-year old pupils that will complement textbooks and other teaching materials used in schools. Moreover, they work on preparing professional development courses and other supporting materials oriented on the development and implementation of inquiry-based learning of mathematics and science. For better implementation of these courses in Slovakia, there is a need for deeper microanalysis that will respect cultural specification.

2 Theoretical framework

In our study we focus our attention on teacher's questioning. One of the main reasons is that we consider asking questions and receiving answers, together with (Foster, 1999) as a self-regulated process of learning. It emerges from individual's natural curiosity and helps to make connections among ideas in human brain. Learning through questions constructs knowledge, understanding, and meaning by finding answers.

There are many different theoretical frameworks for identification of questions that a mathematics teacher asks. In our study, we choose questions that characterize the main activities within the inquiry teaching. Other important characteristic of the framework is that it is easy to use. We will use four categories of inquiry questions that are based on the type of responses a question may elicit (Foster, 1999):

(1) **Confirmation** questions are asked for a simple yes or no answer and are useful indicators of reality. These questions are asking for responses that relate to actions involved in investigations rather than the recall of information provided by a teacher, textbook, or other resources.
(2) **Factual** questions begin with what, when, and where and require learners to give short answers beyond yes or no. Answers to factual questions reveal children's knowledge about cause and effect relationships and patterns that are emerging from the data.
(3) **Process** questions are asked to explain actions used to formulate answers to the other types of questions. Typically, they begin with the words how or what. Learners who can explain their actions become cognizant of how their activities influence and create new knowledge. Answering process questions provide opportunities for children to practice creating explanations.
(4) **Conceptual** questions begin with why. These questions require responses that explain relationships abstracted from factual information. Conceptual questions are the most difficult to ask and answer because they require learners to probe the knowledge they have internalized.

We also need to better understand how teacher educator will approach the unfamiliar content and pedagogy using prepared material. Within this concept we use model presented by (Guskey, 2002, p. 383), where teacher educator can see that the prepared material work. It is an improvement on students' learning outcomes that leads to change in teachers' practice that finally will provoke a change on teachers' beliefs and attitudes. We would like to test this assumption in the university preparation course using the prepared material.

3 Methodology

3.1 Research question

Q1: What similarities and differences of teacher questioning can be observed in the lessons after the repeated teaching of IBL material? (on the basis of experience and reflection the teacher acquires knowledge about possible mistakes, or, possibly, about the discussion of the solution)

3.2 Methods

In our study, we used qualitative methods of data collection and analysis. Because we wanted to observe the teaching of the teacher educator, we decided to use video-based observation which enables us the repeated reviewing of the lessons. After the seminar, we interviewed two students and the teacher educator. We used semi-structured interviews in both cases. The participants had the possibility to reflect on the lessons and to identify the crucial moments.

3. 3 Data analysis

All the videos and interviews were transcribed and coded according to our theoretical framework. We identified the corresponding parts of the seminars that were closely analysed and triangulated within the attaining data (Švec et al., 1998). For the classification of questions, only questions related to the mathematical content of the problem were chosen. We excluded the questions concerning the organisation of the lesson, the work with interactive board, questions quoted from the material as the task of the problem, or the questions used to check whether the teacher understood properly what the students had said.

4 Results

4.1 Description of the situation

The teaching unit was covered in March 2011 in the course called Methods of Solving Mathematical Problems. The participants were two groups of students studying in the first grade of Master's study program Teaching of Academic Subjects: Mathematics in combination with another subject.

Each group of students attended three 90-minute seminars within three weeks, consisting of motivational introduction to the topic, solving of the problems about time from the assignment and the evaluation of the topic by students. In the course of these seminars, an interactive board with the applet of hours was used to model the situations.

4.2 Description of the problem

The materials from the assignment are focused on the tasks about time, hand movements and angles among hour hand, minute hand and second hand. This assignment was used for the Mathematics B-day competition for teams of 3 or 4 students organized yearly by the Freudenthal Institute of Utrecht University in the Netherlands. The teams work on a very open-ended problem situation in which mathematical problem solving and higher order thinking skills must be used to solve the problem. (www.primas-project.eu)

We chose only some tasks from one of the four parts. During the second week, we focused on the following problems:

A1 If the two hands lay as if they are an extension of each other, for example at exactly 6 o'clock, then the two hands produce an angle of 180 degrees. How often in a period of 12 hours are the hands separated by 180 degrees?

A2 How often, in a period of 12 hours, do the two hands form an angle of 90 degrees, of 120 degrees, of 30 degrees?

(http://www.primas-project.eu/artikel/en/1160/In+the+hands+of+time/view.do)

4.3 Pedagogical issues

The teacher educator has to organise student-led inquiry to support students (prospective teachers) with semi-structured, open-problem situations and to judge students' work when various answers and approaches to the problem are possible.

Teacher experiences the work on an unfamiliar problem that does not resemble any mathematical subject learned before. It means that IBL processes, in particular the way in which a solving strategy has to be developed in a group process, are the main focus of the activity. (www.primas-project.eu)

4.4 The comparison of questions in two parallel seminars

We have chosen video sequences from both seminars where the teacher wanted to generalize particular problems and find a general formula for solving the problems from the assignment. Both chosen sequences of the lessons were of about the same length. The sequence from the first seminar lasted 24 minutes and the second seminar lasted 27 minutes and 57 seconds.

The level of difficulty and the process of solution are similar which enables us to compare these two episodes. The topics in the chosen sequences from both seminars are also similar (the angle of 180 degrees on the first seminar and the angle of 90 degrees on the second seminar). Moreover, both groups spent almost the same amount of time on solving those problems.

In both cases, mostly confirmation and factual questions are used and only few process and conceptual questions are present. The number of process and conceptual questions in the chosen sequences from both seminars is almost the same, but, during the first seminar, there are more confirmation questions (35) than in the second seminar (12) and less factual questions (11) than in the second seminar (19) (see Table 1).

Table 1 Overview of questions from two sequences

	180 degrees (56)	**90 degrees (37)**
conceptual questions	4% (2)	2% (1)
process questions	14% (8)	14% (5)
factual questions	20% (11)	51% (19)
confirmation questions	62% (35)	32% (12)

4.5 Illustrations from seminars

In the following transcript, these codes are used:
TE – teacher educator
S – individual student
() – pause, each dot represents one second
[] – explanation from the researchers about the situation in the classroom, content from the white-board
// - codes of questions according to the theoretical framework

Seminar 1

TE: So, we have the universal method, do you agree? /confirmation question/
And, moreover, the method can be improved to be really universal, when I substitute this angle [the teacher circles the angle 180 degrees on the white-board] (.) by some variable, right? [white-board: 11/2 x = 180° + 30°.n; n ∈ {1, ..., 12}] /confirmation question/
Because here, we tried to determine that the angle should be… This, this was actually the universal equation for angle of 180 degrees, wasn't it? (..) /confirmation question/
And how would it be if we took a random angle α? (..) /process question/

S: That α would be from 0 to 180.

TE: Yes, α would be from the interval, we can put it into continuous interval, normally, like this, OK? [the teacher writes on the white-board] [white-board: $\alpha \in \langle 0; 180\rangle$] Is it meaningful? (.) /confirmation question/
From 0 to 180 degrees, random angle, right? /confirmation question/
I can calculate, even to the minutes, not only to degrees. It means that the completely universal equation would be ½ x is α plus 30 degrees times *n*, where for α and *n* there are the same conditions as are written here [the teacher writes on the white-board] [white-board: 11/2 x = α + 30°.n; n ∈ {1, ..., 12}].

Seminar 2

TE: And now, tell me, where it was hidden by now that it is after one o'clock.
S: Here, the number 30.
TE: The number 30. And if it was after two o'clock, how would it change? /factual question/
S: 60.
TE: It would be 60 there. It means that there was 30 times *y*, or 30 times *n*. And where could we add that number 1? /factual question/
S: After... After this.
TE: After number 30. Yes, that means how this general formula would change if we calculated the angle which is not 0 degrees, but which is angle α for example, OK? /process question/
S: So we are going to put it here after... [student writes on the white-board]
TE: Write it. (.) So, we have the general formula, but we want it to be, let's try it, 11/2 x, I'll force you to use the fraction. Because this is the difference. It doesn't matter if I write 5.5 or 11/2 equals 30 times *y* or *n*.
S: Plus the angle which…
TE: Plus the angle which it covered. [white-board: 11/2 t = 30.n + α]

4.6. Interpretation

During the sequence from the first seminar, the teacher spoke for longer time without interruption, asked more questions at once without giving the students the wait time to think about the question and to formulate the answer. She used mostly confirmation questions in which she revealed the facts important for final, generalized formula.

In the second seminar, the teacher had previous experience with teaching the material to students. She knew which facts to ask about to navigate the students to the generalized formula. Therefore, she asked factual and process questions which are in a higher level in inquiry questions classification. Obviously, there were more dialogs during the chosen sequence from the second seminar compared to the sequence from the first seminar. The teacher asked shorter questions focused on specific facts expecting that the students would know the answer. The answers of students were also short and clear.

When comparing these situations from both seminars, the teacher educator was more certain when teaching the lesson for the second time, she used different categories of questions for achieving her aim. This was also confirmed by the teacher educator during the interview after teaching both seminars.

> "And I was more certain, because, actually, I had it for the second time repeated. That I solved the problem once that I had quite good picture about them […] so I was able to ask questions more directly."

She also suggested the improvement of the above mentioned situations if taught next time.

> "I realized that we could actually create such individual equations, or concrete equations for random angle, or this way, for all those angles which were given. It means there were 0 degrees, 90 degrees, 120 degrees and 30 degrees. And if we wrote those four equations under each other… […] And go, and went from this…"

5 Discussion

When we looked at the data, we can see that the most questions are confirmation and factual questions in both seminars. The difference between the two lessons is that during the first seminar, there are more confirmation questions when compared to the second seminar and less factual questions when compared to the second seminar. We can also observe that there are only a few conceptual and process questions in both sequences. Possible explanation is that the teacher educator is trying to model the inquiry process and that is why she presents the inquiry process in the classroom and used the confirmation questions for attracting students' attention to follow her inquiry process. The second seminar is different in the way that there are more factual questions because the teacher educator stresses more the facts that could serve as a mediator for better understanding and they get the overview about the problem. Another factor is that students were more prepared for the seminar and came with the ideas faster than the first group. In our analysis, we didn't consider the different disposition and performance of students in each of the seminars. Even though this data may influence the atmosphere at the seminars, it did not contradict to the shift of teacher educator learning.

This shows that the teacher educator improved her questioning to a higher level within our theoretical framework. The main reason for that we see in experience and reflection after the first seminar. This need to be valued also in further possible professional development courses. In our further study, we would like to extend our analysis of IBL pedagogy implementation, that will look at the same data from perspective of different theoretical framework which could give a more holistic view on the situation that would offer unique information for the implementation of IBL pedagogy in mathematics education in Slovakia as well as help in designing professional development courses for in-service teachers.

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7 References

ASKING QUESTIONS THAT ENCOURAGE INQUIRY-BASED LEARNING: HOW DO WE ASK QUESTIONS TO DEVELOP SCIENTIFIC THINKING AND REASONING?. [2011-3-23]. Available at: <http://primas.mathshell.org.uk/pd/modules/4_Asking_questions/pdf/4_Asking_questions.pdf>

CLARKE, D. - HOLLINGSWORTH, H. 2002. Elaborating a model of teacher professional growth. In Teaching and Teacher Education, vol. 18, p. 947–967.

FOSTER, G. 1999. Elementary Mathematics and Science Methods: Inquiry Teaching and Learning. California: Wadsworth Publishing, 1999. 400 p. ISBN 978-0534515799

FRADD, S.H. - LEE, O. - SUTMAN, F.X. - SAXTON, M.K. 2001. Promoting science literacy with English language learners through instructional materials development: A case study. In Billingual Research Journal, vol. 25, p. 417-439.

GUIDE FOR PROFESSIONAL DEVELOPMENT PROVIDERS. [2011-07-05] Available at: <http://www.primas-project.eu/servlet/supportBinaryFiles?referenceId=5&supportId=1247>

GUSKEY, T.R. 2002. Professional Development and Teacher Change. In Teachers and Teaching: theory and practice, vol. 8, p. 381-391.

IN THE HANDS OF TIME. [2011-04-29]. Available at: <http://www.primas-project.eu/artikel/en/1160/In+the+hands+of+time/view.do>

KORŠŇÁKOVÁ, P. - KOVÁČOVÁ, J. - HELDOVÁ, D. 2010. Národná správa OECD PISA SK 2009. Bratislava : Národný ústav certifikovaných meraní vzdelávania. Available at:

<http://www.nucem.sk/documents/27/medzinarodne_merania/pisa/publikacie/Narodna_sprava_Slovensko_PISA_2009.pdf>

MATEMATICKÁ GRAMOTNOSŤ VO VÝSKUME PISA 2003. [2010-02-26]. Available at: <http://www.ineko.sk/ostatne/matematicka-gramotnost>

ŠVEC, Š. et al. 1998. Metodológia vied o výchove. Bratislava : IRIS, , 303 p. ISBN 80-88778-73-5

WALKER, M. 2007. Teaching inquiry based science. LaVergne, TN: Lightning Source, 2007. 160 p. ISBN 978-1847999320

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