Acta Mathematica Nitriensia
Vol. 5, No. 1, p. 23-28
ISSN 2453-6083

Inquiry-based Mathematics Education: Examples of Solved Tasks of Primary School

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Received March 15, 2019; received in revised form April 10, 2019; accepted April 12, 2019

Abstract

In this paper we analyze and discuss about implementation of inquiry-based teaching (IBT) into mathematics education. Pupils naturally explore and learn through inquiry, different interesting problems or controlled activities for this inquiry have priority. Also computer technologies (in any form) offer an accessible environment for such a pupils´ work. We describe this education from the perspective of the pupil and the teacher; also mention its goals and what pupils can learn in this way. Various tasks based on inquiry-based teaching are presented in the paper, too. These tasks are related to teaching according to educational domains at lower secondary school in Slovakia.

Keywords: inquiry-based teaching, inquiry, activities, pupils, educational domain.

Classification: D30, D50

Introduction

Generally, in different types of schools, the relationship of pupils to mathematics and other science subjects is not very positive. That is why we think it can help pupils understand when we bring the educational process closer to real life. It is also appropriate to motivate pupils to develop their inquiry skills.

In this way, the pupil can seek answers by experimenting, creating theory, models, looking for appropriate arguments to explain, formulating conclusions from his findings, etc.

In this paper, we focused on IBT in mathematics; we will also give a look at this education from the perspective of the pupil as well as the teacher. We present principles of inquiry-based teaching on specific examples. These examples are related to selected educational domains according to State Educational Program – Mathematics for the lower secondary education – ISCED 2 (2014) of Slovak Republic.

Inquiry-based teaching in mathematics education

In pedagogical understanding, the word inquiry occurred with the author Dewey (1997) while its definition of inquiry is a method of tested discovery that cultivates „deep-seated and effective habits of discriminating tested beliefs from mere assertions, guesses and opinions; to develop a lively, sincere, and open-minded preference for conclusions that are properly grounded".

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DOI: 10.17846/AMN.2019.5.1.23-28

In an inquiry classroom, concepts are introduced in order to illuminate a mathematical process that all participants have the chance to direct. Yet it is the responsibility of the teacher as „a more experienced knower" to select students' ideas that provide a link to mathematical concepts. (Goos, 2004)

A model of learning science thorough inquiry can see in the schema reproduced in Fig. 1.

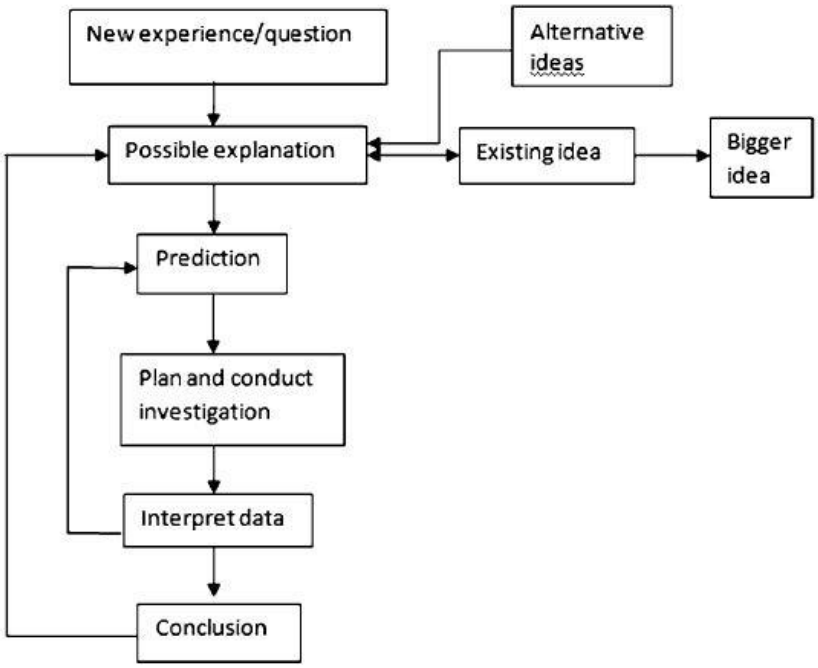

Fig. 1: A model of learningscience through inguiry (Artigue – Baptist, 2012)

So as author Blair (2014) state what with this model of teaching pupils can learn to: ask questions, make conjectures, plan and monitor their activity, explore ideas in collaboration, explain their reasoning, identify when they need new knowledge, ask the teacher for an explanation or prove their results. On the contrary, teachers' goals are harness students´ curiosity, connect concepts and procedures, support student regulation, co-construct open inquiries, combine different forms of reasoning or develop students´ initiative, independence and leadership.

Educational domain: Numbers, variables and counting with numbers taught by IBT

Now we present an activity for understanding the concepts of prime number and compound number. We can also develop abilities to find all the divisors given figures. The dominant method is controlled inquiry for pupils working in groups. This activity is suitable for 6th class (12 – 13 years old pupils).

Author Semanišinová (2018) states how pupils can play the following game: Each player is assigned his own color (such as player A blue and player B red). Player A marks any unmarked number on the game board in blue. Player B then tries in red to mark as many unmarked divisors as the player has selected A. After player B has marked the unselected number divisors, he selects the next number for player A and marks it with his color. Player A then marks his divisor with his color. In the event that a player on the move has selected a number that has no unmarked divider on the board, the player loses the move. The number

is marked in black (or crossed out) and the next number is selected by the opponent. The game ends when only numbers that do not have unmarked divisors are unmarked on the game board. Each player counts his or her marked numbers on the game board. The player with the greater total of points wins. Example of one game is shown in Fig. 2.

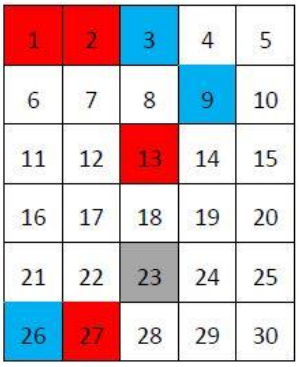

Fig. 2: Possible course of the game (Semanišinová, 2018)

Each pair of pupils plays games twice (each game starts with a different pupil from the pair). Intermediate results of pupils are recorded in a table such as we can see Table 1.

***Table 1**: Selected numbers by pupils (Semanišinová, 2018)*

I have a number	**Divisors of numbers**	**Unselected number divisors**	**Selected number**
			29
28	1, 2, 4, 7, 14, 28	2, 4, 7, 14	27
22	1, 2, 11, 22	11	25
18	1, 2, 3, 6, 9, 18	6	30
16	1, 2, 4, 8, 16	8	26
24	1, 2, 3, 4, 6, 8, 12, 24	12	
	Counted out	64	137
		Counted out	201

Pupils play two games and then together pairs are answering such questions of teacher: „Is it preferable to choose 27 or 17 in step 1? Justify what you chose"; „Which number is preferred to choose in the first step?"; „Which number is not a good choice in the first step?"; „Which number has the most divisors?"; „Which number has an odd number of divisors?" or „Describe how you played the game. What moves do you think are beneficial?". In the end, pupils do self-evaluation how to play the game to be successful in it.

Pair pupils present their answers to questions. They together discuss with teacher about possible answers, also formulate arguments. After this discussion, we define the concepts of prime number and composite number to the pupils.

Then pupils solve four tasks in worksheets individually (see Table 2):

***Table 2**: Tasks in worksheet*

Task 1: Fill in the following table:

Number	Divisors of number	Prime number/ composite number?
1		
2	1, 2	Prime number
…	…	…
30	….	…

Task 2: See the picture below. The number is chosen by the red player.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30

a) What happens if you this player choose a prime number?

b) What composite number should I choose? Explain why.

Task 3: Decide whether the numbers 19, 31, 45, 51, 63, 67, 91 and 99 are prime numbers or composite numbers.

Task 4: Is there a number that has an odd number of divisors?

Educational domain: Geometry and measurement taught by IBT

Following activity is devoted to geometry for 5th class (10 – 11 years old pupils). Knowledge and skills acquired by pupils are concepts as cube structure (also its plan) and cube body (and also its plan). The dominant method is controlled inquiry for pupils working in groups (possibly pupils can work separately) and working with a computer is also recommended.

The 5E Inquiry-Based Model is used during the lesson of mathematics. In phase Engage pupils work with the first worksheet called „What do you remember about cubes structure from the 4th grade?". Following the Engage is the Explore and teacher formulates the problem about cubes structure or cube body, pupils in controlled inquiry proposes a procedure for drawing a plan of these buildings. During the Explain phase, there is an explanation of all the examined terms in cooperation of the pupil-teacher. The Elaborate phase of the 5E Model is meant a solution to another worksheet with problem tasks. The final phase of this model is the Evaluate, where the teacher formally evaluates pupils' work.

Now we are presenting specific examples of worksheets used during the pupils´ inquiry. Pupils work with that first worksheet and they use given cubes structure (see Fig. 3).

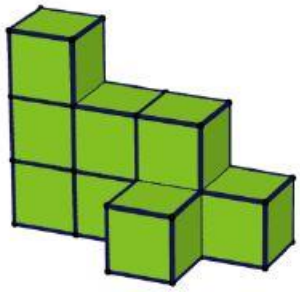

Fig. 3: Cubes structure for pupils´ inquiry

During the pupils' work, the teacher asks the following questions: „Describe the cube and cube structure"; „What do you mean by coding of cube structure?"; „What the plan numbers mean?"; „What do you mean by column, row, floor? (Point at the cubes structure in front of you)"; „Which means top, bottom, front, rear, right, left?". (Záhorská, 2017)

After the work of pupils with the second worksheet pupils know the difference between concepts cube structure and cube body. Also, pupils can draw their plan to them (Fig. 4).

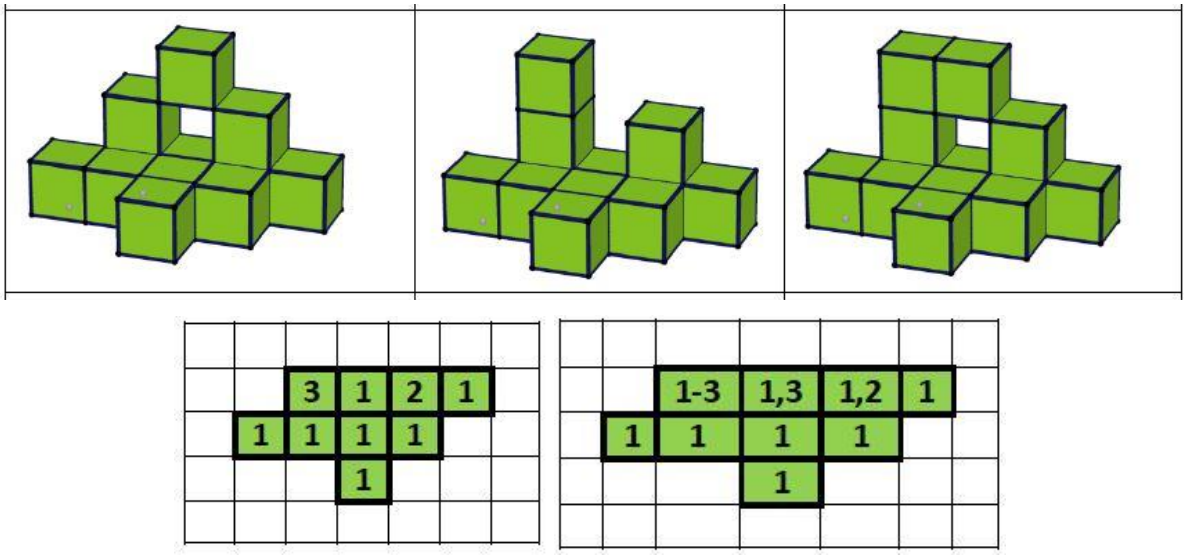

Fig. 4: Examples from the worksheet 2

Work with the pupils is evaluated during the math lesson. Teacher evaluates the work of the pupils formatively. The conclusions that pupils have reached must also be highlighted. In addition to the above formative assessment, the teacher may also use symbols, for example 🙂 and ☹.

Conclusion

In this paper we have shared our experiences with IBT. We are looking to increase the interest of math education and include a more engaging way of teaching by including IBT or information and communications technology. By working in groups, pupils help each other and, by presenting the results for a group, inspire individuals who have difficulty presenting their own results. We share the view that this method is suitable for teaching mathematics although it is more time-consuming to prepare a teacher or a pupil's work during lesson.

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