PUPILS’ ROLE AND TYPES OF TASKS IN ONE-TO-ONE COMPUTING IN MATHEMATICS TEACHING

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The article presents results of data analysis of 11 mathematics lessons (29 episodes) in which netbooks were used within one-to-one computing. The research questions were: What is the pupil’s role in teaching in which netbooks are used? How does he/she participate in the solution to the task using the netbook? What are the types of tasks solved with the support of netbooks? The result of a qualitative analysis is a classification of tasks and of pupils’ participation in the solution to tasks using netbooks (examples are provided). It was found out that traditional types of tasks and a pupil as a spectator or user prevail. It ties with other research and points to the key role of developing teachers’ technological pedagogical content knowledge.

Keywords: netbooks, one-to-one computing, pupils’ participation, task types

INTRODUCTION

A relatively new type of ICT integration in the teaching of mathematics consists of so called digital classes in which each pupil has his/her own laptop with installed electronic textbooks and software for school and home work (one-to-one computing). Classrooms are equipped with a data projector, an interactive whiteboard and internet connection. There are many studies about one-to-one computing, however, only few concern mathematics. For example, a study in a Grade 3 class has shown that the integration of laptops into the learning environment is a very complex process and that the key role is played by teachers (Neumajer, 2009). While the teachers welcomed the possibility of work with laptops at the beginning, they more or less impeded their more intensive use. Teachers mostly used laptops as a substitute for usual didactic means within a traditional frame of teaching. Similarly, Billington (2011) who investigated the teaching of mathematics at an upper secondary school concludes that laptops were mostly used within the curriculum – tasks could have been solved without them. Laptops strengthened the existing way of teaching rather than changed the teaching practice.

Freiman et al. (2011) describe a project in which Grade 7 and 8 pupils were equipped with laptops for use in several subjects. The authors conclude that “laptops in and of themselves may not automatically lead to better results on standardized tests, but rather create opportunities to enrich learning with more open-ended, constructive, collaborative, reflective, and cognitively complex learning tasks” (p. 136).

Vondrová & Jančařík (2012) analysed videorecordings of 15 primary mathematics lessons with netbooks and conclude that the episodes with netbooks concerned mostly revision and practice tasks and the teachers’ explaining a new topic; tasks leading to the creation of knowledge by pupils were not seen. The “netbooks were utilised for activities easily accomplished without them (such as reading a text)” and “except for the applets in which pupils can work at their own pace and can often choose the level of difficulty, we did not witness any incidence of the teacher asking pupils to work on different tasks”.

One-to-one computing is a rare phenomenon in the Czech Republic. There are local projects with netbooks which usually aim to enhance pupils’ motivation, engagement in mathematics and knowledge, to promote individualized learning, to use more complex tasks which are difficult without ICT, etc. This paper aims to see, broadly speaking, whether this expectation has been fulfilled in one such project.

THEORETICAL BACKGROUND

It is generally accepted that the key elements influencing pupils’ learning of mathematics are tasks and the way the tasks are implemented in lessons – in this implementation, an active role of the pupil in developing knowledge is usually stressed. For example, the concept of *opportunity to learn*, seen as the single most important predictor of pupils’ achievement, is defined as the “circumstances that allow students to engage in and spend time on academic tasks such as working on problems, exploring situations and gathering data, listening to explanations, reading texts, or conjecturing and justifying” (Kilpatrick et al., eds., 2001, p. 333). It includes “considerations of students’ entry knowledge, the nature and purpose of the tasks and activities, the likelihood of engagement, and so on” (Hiebert, Grouws, 2007, p. 379). Hiebert & Grouws (2007) point out that the teaching in which pupils are *struggling* with important mathematics leads to conceptual understanding. By struggling, they mean pupils expending “effort to make sense of mathematics, to figure something out that is not immediately apparent”.

The tasks and their implementation is a matter of concern in teaching with PCs, too:

> This is where the big issue is – the nature of the tasks and how they are presented to students. These should enable the student to experiment, investigate and draw conclusions. Students need to have access to the computer in the class, and the activities proposed should be rich enough and appropriate to promote learning. (Amado, 2011, p. 2150)

Thus, we are concerned with the way tasks are implemented in the digital class and what role pupils have in their solutions using netbooks – how engaged they are, if they struggle in the above sense or if they are invited to struggle at all.

There is a growing body of research focused on the types of mathematical tasks set in digital classes. One typology concerns the role technology plays in the solutions to the tasks (Böhm et al., 2004):

- Tasks where the use of PC and software is of little or no help; the solution is faster by-hand.

- Tasks that are solved faster or even trivialised by PC.
- Tasks testing the ability of using PC and software.
- Tasks starting from traditional ones that are extended to PC tasks (e.g., by including formal parameters or using realistic data).
- Tasks difficult, time consuming or impossible to solve without PC.

Another classification is introduced by Assude (2007): tasks of developing: instrumental knowledge and skills, mathematical knowledge and skills, relations between instrumental and mathematical knowledge and skills.

Zbiek et al. (2007) distinguish *technical* and *conceptual mathematical activity*. The former includes geometric construction and measurement, numerical computation, algebraic manipulation, graphing, translation between notation systems, solving equations, creating diagrams, etc. The latter involves understanding, communicating, and using mathematical connections, structures, and relationships, defining, conjecturing, generalizing, abstracting, etc. The authors stress that neither type of activity is more mathematically meaningful than the other.

Another point of view Zbiek et al. (2007) introduce is that of the initiator and maintainer of the activity. They distinguish *exploratory* and *expressive activity*. In the former, pupils are asked a question and given a procedure to carry out by the teacher; e.g., one type is “guided” exploration in which the pupils’ goal is to produce a predetermined result chosen by the teacher. In the latter type of activity, pupils decide which procedures to use; they attempt to answer a question of their choosing with their choice of process. Zbiek at al. stress that “the nature of students’ exploratory or expressive work depends on both the task and the activity” (p. 1181).

Finally, Zbiek et al. (2007) distinguish between the use of technology as *amplifier* and as *reorganiser*. The former accepts the goals of the current curriculum and works to achieve those goals better. The latter changes the goals of the curriculum by replacing some things, adding others, and reordering others.

To sum up, PCs seem to provide a good opportunity to use rich activities in such a way that pupils struggle in the above sense, however, this opportunity is not often fulfilled. For example, the meta-study *The ICT Impact Report* (European Schoolnet, 2006) states: “Teachers’ use of ICT for communication with and between pupils is still in its infancy. ICT is underexploited to create learning environments where students are more actively engaged in the creation of knowledge rather than just being passive consumers.” Laborde at al. (2006), investigating the use of Cabri, conclude that teachers use it within a static geometric curriculum, i.e., traditional content and methods, and thus do not make use of educational powers of ICT.

Research has shown that also within ICT teaching, the key role of what is learned and how it is done is played by the teacher (e.g., Lozano & Trigueros, 2007; Fuglestad, 2005). Mishra & Koehler (2006) develop a model of the types of knowledge teachers need to teach with ICT. *Technology Knowledge* involves the skills required to operate technologies. *Technological Content Knowledge* is knowledge about the relationship between technology and content, i.e., how the content can be changed by the application of technology. *Technological Pedagogical Knowledge* is “knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies”. The central part of the model is *Technological Pedagogical Content Knowledge* (TPCK) which “requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students’ prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones” (p. 1029).

METHODOLOGY

In 2009, Grade 6 pupils in three classes in different schools were given one netbook each. The netbooks have been used in several subjects including Mathematics. The three teachers whose lessons are available to us were young, with several years of teaching experience. A publishing house that publishes, among other, e-textbooks provided them with training which concerned Technology Knowledge (use of netbooks, the interactive whiteboard, pupils’ and teacher’s software), Technological Content Knowledge (the use of the e-textbook, which includes multimedia, hyperlinks, e-tasks, etc., the use of dynamic geometry software, etc.) and partly Technological Pedagogical Knowledge (the way pupils can work in pairs, at the interactive whiteboard, how to create and use interactive exercises on the board and in netbooks). The teachers were rather passive during the training; they were not required to prepare digital material themselves. In other words, they were expected to develop their TPCK themselves during their teaching. At the beginning of the project, their attitude towards ICT was positive and they believed in its potential benefits for pupils’ learning.

We have revisited some of the data used for Vondrová and Jančařík’s work (2012) and analysed them from the following perspectives:

1. What are the types of tasks which are solved with the support of netbooks?

2. What is the pupil’s role when netbooks are used in the lessons? How does he/she participate in the solution to the task with the help of the netbook to reach the goal of the task?

The data consist of videorecordings of 11 lessons, in which netbooks have been used, in Grade 6 and 7 in three schools. The videorecordings were made by us or the school provided us with them. The camera was typically static, at the back of the classroom recording the whole class and zooming in on the teacher and/or the whiteboard from time to time. The videorecordings come from different parts of the school year. At the time of our first observations, the teachers had had about half a year experience with using netbooks in their teaching. Thus, they already possessed necessary Technical Knowledge and their pupils had had an opportunity to familiarize themselves with netbooks and the software.

The analysis of videorecordings started by distinguishing episodes with netbooks, spanning between 5 and 20 minutes (Tab. 1). By an episode, we mean a part of the lesson where one task was used. The episodes were coded in terms of the type of task used and the pupil's engagement in the solution to the task with the help of the netbook. We were only concerned with the part of the solution to the task which was done on the netbook, mostly disregarding the paper and pencil solution.

The coding was based on the above types of tasks but we also used techniques of grounded theory for coding the new emerging aspects of the tasks and their implementation. The coding stage resulted in a list of codes which were organised into two categories – pupils' engagement and types of tasks.

	Grade 6		Grade 7	
	No. of lessons	No of. episodes	No. of lessons	No of. episodes
Teacher X	3	3 / 5 / 3	1	4
Teacher Y	2	1 / 1	2	4 / 3
Teacher Z	2	3 / 1	1	1

Tab. 1. Number of lessons and episodes with netbooks

As an example, we will present the coding of three episodes from one lesson.

<u>Grade 6, February 2011. Topic: Practical use of volume and surface area of cuboids.</u>

<u>Episode 1:</u> Each pupil works on the internet with an interactive exercise to practise calculations of volumes and surface areas of cuboids. First, they recognise cuboids from among different solids which have sizes of edges given and record calculated volumes and surface areas in the box provided on the screen. The applet returns an immediate feedback whether the result is correct or not.

<u>Codes:</u> *Pupil as a user* (works according to instructions on the website), *Traditional task* (distinguishing solids, calculating volume and surface area), *Technical mathematical activity* (numerical computations), *Netbook as amplifier*.

<u>Episode 2:</u> The teacher sent the pupils a Smart Notebook presentation by wifi, the same presentation is open on the interactive whiteboard. The presentation shows some objects such as a house, a box, an aquarium and the pupils' task is to assign a box with dimensions $a \times b \times c$ to each object; that is, they should estimate measures of real objects and use units such as dm, cm and m correctly.

Codes: *Pupil as a user* (works according to instructions), *Traditional task* (estimation of lengths, understanding units of measures), *Technology* (namely, practising the dragging tool in Smart Notebook), *Technical mathematical activity* (estimation of dimensions, conversion of units), *Netbook as amplifier*.

Episode 3: Another task in the same presentation as used in Episode 2. The task is to calculate the height of water in a swimming pool if we know its volume and dimensions of the bottom. The teacher asks the pupils to use the pen in Smart Notebook and colour edges of the bottom base in the pre-drawn cuboid. Next, they should use the blue pen to record the water level – lower than the upper base of the cuboid. Some pupils cannot do it and wait for the teacher to do it on the interactive whiteboard. The cuboid is moved away and the pupils draw vertical edges according to the teacher's instructions and they can "see" a cuboid again: "a cuboid of water in the swimming pool". The teacher refers to an analogical task solved earlier.

Codes: *Pupil as a user* (works according to the instruction), *Traditional task* (calculating the height of the cuboid when the volume and measures of the base are given), *Technology* (namely, practising tools – coloured pens, deleting an object), partially *Mixed task* – the solution is supported by visualization (a picture of a swimming pool – water in the pool "makes" a cuboid), *Technical mathematics activity* (calculation of volume), *Netbook as amplifier* (visualization of ordinary mathematics situation), *Exploratory activity* ("finding" a cuboid of water).

RESULTS

The first focus of the analysis was on the **types of tasks** which were assigned in the lessons and for which netbooks were used. Two aspects were followed: whether tasks were used for the development of knowledge and skills connected to mastering the netbook or mathematics, and whether the netbook with its software helped in the solution to tasks. Four types of tasks have been distinguished:

- *traditional tasks* which can easily be solved without netbooks and for which netbooks only replaced paper-and-pencil techniques; netbooks were of no help or they only made the solution faster (13 episodes); the episodes included technical mathematical activities and 3 also conceptual activities; 1 episode included an exploratory activity.
- *computer oriented tasks* which developed computer skills through solving a traditional mathematical task (8 episodes); all included technical mathematical activity and 3 conceptual activity, too; 1 episode was with an exploratory activity.
- *mixed tasks* for which the netbook and its software markedly simplified the solution or made it more illustrative, understandable (2 episodes); both consisted of a technical mathematical activity and exploratory activity, one included a conceptual activity, too.

To make the classification complete, we add one more type of tasks which did not occur in our data and which we, in view with Böhm et al. (2004), see as an ultimate goal of teaching with ICT:

- *computer tasks* which would not be possible without the support of the netbook; e.g., the algorithm is too complicated, the task is too numerically demanding, etc.

Thirteen episodes were not classified in terms of the task used. In 11, the pupils only read an assignment on the screen and did not use the notebook for the solution at all, in 1 episode they searched the internet for the word election and in another one they used the notebook for sending the teacher their homework by wifi. We did not witness any use of netbooks as reorganisers neither any expressive activity.

When solving tasks using netbooks, naturally the technical aspect plays a role. Thus it is quite difficult to distinguish which type of tasks of the proposed classification was the primary one, whether mathematically or technologically oriented. For example, in one of the episodes pupils look for the least common multiple of three different numbers. They use tables in Excel in which they are to generate multiples of the numbers. The teacher soon finds out that some pupils fill in the numbers manually and thus goes on to explain the solution in terms of technology – how to make the table with multiples in Excel automatically. The same problem with Excel appeared in the same class a month before this episode. A potentially *computer task* has become a *computer oriented task.*

The second focus of the analysis was on the type of **pupils' participation in the solution to the task with the help of netbooks**. The following classification has emerged in our data:

- *a pupil as a spectator* – pupils only observed what was going on on the screen of the netbook, they did not use any tools available on the netbooks; typically the pupils were asked to read the assignment of the task from the e-textbook or observe a demonstration (14 episodes).
- *a pupil as a user* – pupils worked on the netbook according to the instructions of the teacher or the textbook, e.g., substituted numbers into the teacher's Smart Notebook presentation, used a mathematical applet for practising algorithms; we could say that the netbook substituted a worksheet with tasks to be completed but with a possibility of feedback (12 episodes); all episodes concerned technical mathematical activities and the netbook was used as an amplifier; one episode was classified as an exploratory activity and one as a conceptual activity.
- *a pupil as an active user* – the netbook was an important tool for pupils, they used its software to look for solutions to the task by, e.g., geometric constructions, computations, graphing, etc., or by looking for relationships, experimenting and making deductions; the netbook helped in the solution (4 episodes); the task was set by the teacher, who, through the choice of software, usually determined the

solving methods, but the pupils could also make their own choices; all episodes were coded as amplifiers, 2 episodes as exploratory activities and 3 combined technical mathematical and conceptual activities.

Again, to make the classification complete, we suggest one more type of pupils' role which was not observed in our data:

- *a pupil as an independent and active user* – pupils use the netbook purposely to develop their knowledge and skills; if we paraphrase Amado (2011), the netbook is their partner in the learning process, "enabling [them] to achieve some knowledge that would otherwise be very difficult or even impossible".

In most episodes, the pupils' work was controlled by the teacher, the pupils were rather passive even in potentially computer tasks. Let us consider one episode in which the centre of the circumscribed circle of a triangle is looked for. The task is as follows: *Find a place for a feed depot for deer which has the same distance from three given feeding-racks which make a triangle.* Several pupils make some drawings in their paper exercise books and hypothesise that it will be a centre of gravity. One pupil makes drawings on the interactive whiteboard. The teacher says that it is not the solution and asks the pupil at the board to refute the hypothesis by using a figure in GeoGebra. The other pupils are asked to "try it yourselves that it will not work". The teacher's instruction is not clear, only several pupils work with netbooks, the others look at the board. The hypothesis is refuted. The teacher continues by giving hints towards the intersection of axes of sides. He asks one pupil to show this solution on a whiteboard using construction tools. The other pupils should make constructions into their exercise books. The situation potentially *a pupil as an active user* was classified as *a pupil as a user* as the teacher took a complete control of the situation. A potentially *mixed task* has become a *traditional task.*

There were only 4 incidents of *a pupil as an active user*. For example, in one of them the teacher sent his own Smart Notebook presentation to the pupils in which a task was given: *There is an ancient temple with columns 60 m apart. We are to relocate the columns so that they are 45 m apart. Which ones will stay?* There is a picture of the temple and columns which can be moved by dragging. The teacher asks pupils to model the situation. The pupils experiment, relocate the columns by dragging, use the ruler on the screen to measure the distances. Not all the pupils find the solution. The teacher uses the problem to formulate the concept of the least common multiple. Smart Notebook was used for the visualisation of a mathematical situation and for experimentation and discovery of the solution. The teacher prepared a task and appropriate means of visualisation which determined the pupils' solving method.

CONCLUSIONS

The above four types of tasks can be combined with the four pupils' roles; e.g., we saw examples of computer oriented tasks in which pupils were users and active users. In a few episodes, types of tasks from the literature review were seen. Let us now take into account the *potential* of the four types of pupils' role. Netbooks as amplifiers as well as technical mathematical and conceptual activities could occur in all types of roles. An expressive and exploratory activity as well as netbooks as reorganisers will not occur in *the pupil as a spectator* as the netbook is not used for the solution at all. An exploratory activity can appear in *the pupil as a user* and *active user* while the expressive activity would tie with *the pupil as an active user* and *an independent and active user*. More data is needed in order to see whether this potential is fulfilled in practice.

The prevalence of traditional tasks and the pupil's role as a user or spectator in the episodes with netbooks tie with results of some other research focusing on ICT tools (Billington, 2011, Neumajer, 2009, European Schoolnet, 2006). It can be caused by the teacher's fear of sudden teaching situations (Laborde et al., 2006) or it can be related to the teacher's little experience with the ICT tools (6 to 12 months in our study). Providing teachers with technology and technological content knowledge is not enough. It is necessary that their TPCK is explicitly developed (see, e.g., Mishra & Koehler, 2006). The teachers go through stages. For example, when integrating Cabri in their teaching, the teachers begin with the use of software as a visual amplifier and end with creating tasks for pupils in which software plays a key role (Laborde, 2001). It might be interesting to see how the situation will develop for our teachers – pupils in the observed classes are in Grade 9 now and thus we plan to analyse data from Grades 8 and 9 to see whether there has been any progress.

Our study has its limitation in terms of data. More lessons or a series of lessons of one teacher would be desirable. The episodes were analysed in terms of an "average" pupil's participation. Still, we believe that the study uncovered some aspects of real teaching with netbooks if teachers are not supported in professional training.

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