Analysis of Approaches to the use of ICT in the Teaching of Mathematics

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Abstract: Information and communication technologies (ICT) play an increasingly important role in learning and teaching. The way they are used in specific lessons is influenced by a number of factors, one of the most important of which is the teacher's beliefs about the use of ICT in education. The way teachers think about modern technologies is very important and greatly influences how they use ICT in their teaching. Our paper presents a partial output of research focusing on the influence of teachers' beliefs on the use of ICT in teaching. Within the presented research, lessons of several mathematics teachers were recorded longitudinally. The recordings from classes were subsequently coded by a team of researchers and analysed in detail on the basis of Grounded theory. Several different aspects of teaching were observed in the analysis: Forms of instruction, Teacher-pupil communication, Pupil activities at the blackboard, Pupil activity on PC or laptop, ICT involvement, Teacher activities, Phenomena in teaching using ICT, Used programs and applications and Testing. The results of this analysis were then compared with how teachers think about the use of ICT and how they characterize their own use of ICT in teaching. Even though all the monitored teachers characterized themselves as experienced users of ICT, the way they used technologies in their teaching was very different and often differed greatly from the positions they declared. As part of the paper, we present a comparison of the teaching styles of individual teachers and a comparison of their beliefs and proclamations with the reality that was observed in the lessons. Attention will also be paid to the impact of the actual use of ICT on the overall course of the lesson and the activity of the pupils. The results of the research show that the way in which the teacher's beliefs affect teaching is really crucial.

Keywords: ICT in education, interactive whiteboards, teachers' beliefs, mathematics education

1. Introduction

This paper presents partial results of a research that was part of the dissertation of one of the authors of the article (Havelková, 2021). It is an analysis of lessons of three mathematics teachers, focusing on the relationship between the use of information and communication technologies in teaching and their beliefs about the role technologies should play in education. The research has shown that although all three teachers have described themselves as experienced users of technology in their teaching, the reality we encounter in their lessons is quite different. An important finding is the fact that it is not enough just to observe whether and for how long technologies are used in lessons. We must also focus on how they are used. The mere presence of technology in lessons may not in itself be an indicator that technology supports teaching and learning. This is shown especially in the use of data projectors and interactive whiteboards that are used by the teachers but the way they are used brings nothing in addition to what classical teaching aids bring.

2. Use of ICT and teachers' beliefs

The role ICT plays in education has been growing. This even more in consequence to the two years of the pandemic that drastically limited the possibility of teaching on-site and that brought emergency remote education (Bozkurt, Sharmaa, 2020). In this period, the vast majority of teachers began to use ICT. Even after returning to presence teaching, ICT is used much more intensively than before. However, the method and intensity of its use varies from school to school and from teacher to teacher. The use of computers is affected by a number of factors. Liu (2011) identifies thirty individual items that might affect using technology and through factor analysis defines six factors derived from these items. These factors are teaching implementation, instructional design, teachers' individual mindset, external expectations, school support, and student achievement. Although this list of factors is rich, it is not exhaustive. We focus on teachers' individual mindset. These factors describe a mindset of individual teachers, which comes from their personal characteristics (settings). These factors include teacher's resistance to adopting new approaches (Handel, 2003), their risk-aversion (Howard, 2013), personal self-confidence and teaching self-confidence (Stipek at al, 2001), desire for professional development. These factors may or may not be connected with their personal beliefs or teacher beliefs. Teachers§ beliefs are "the individual conceptions about desirable ways of teaching

and conceptions about how students come to learn" (Beijaard, 1998). Teacher beliefs have been studied in many papers (e.g., Blay & Ireson, 2009, Zohar, Degani, & Vaaknin, 2001, Correa at al, 2008). Much research shows that teacher beliefs have a strong impact on teaching practices across different classes and grade levels (Kagan, 1992; Kane, Sandretto & Heath, 2002; Pajares, 1992) because beliefs influence teachers' behaviours (Ajzen & Madden, 1986) and have stronger influence on teachers than knowledge (Kagan, 1992; Pajares, 1992; Nespor, 1987). Studies show that teachers' beliefs are key to making teachers´ decision about integrating technology (Becker, 2001; Dede, 2000). They could be helpful for integrating technologies but at the same time, they could be a barrier (Ertmer, 2005). But despite the fact that teachers' beliefs affecct the use of technology, they are not always consistent with real classroom practices (Ertmer et al., 2001) and the relationships between teachers' beliefs and classroom practices are not direct (Fang, 1996; Kane, Sandretto & Heath, 2002) because there are many other factors that have impact on its actual use.

3. Research methodology

The main part of the research was the analysis of recordings of lessons of three teachers (Rudolf, Petr, Jana). Mathematics lessons of each of them were video recorded for two weeks. A total of 43 teaching lessons (see Table 1) were recorded in different classes. In the end, only one class of each of the teachers was included in the detailed analysis, which, in the authors' opinion, best described their typical approach to teaching and technology. The detailed analysis thus worked only with 25 lessons.

Table 1: Number of recorded and selected lesson

	Number of recorded lessons	Selected for research
Rudolf	9	9
Petr	14	7
Jana	20	9

The video recordings were made on a camera on a tripod. It is important for the validity of the results that no changes in pupils' and teachers' behaviour could be observed after the installation of the camera. In accordance with the Grounded theory, the video recordings were coded in the Atlas.ti programme (see Figure 1).

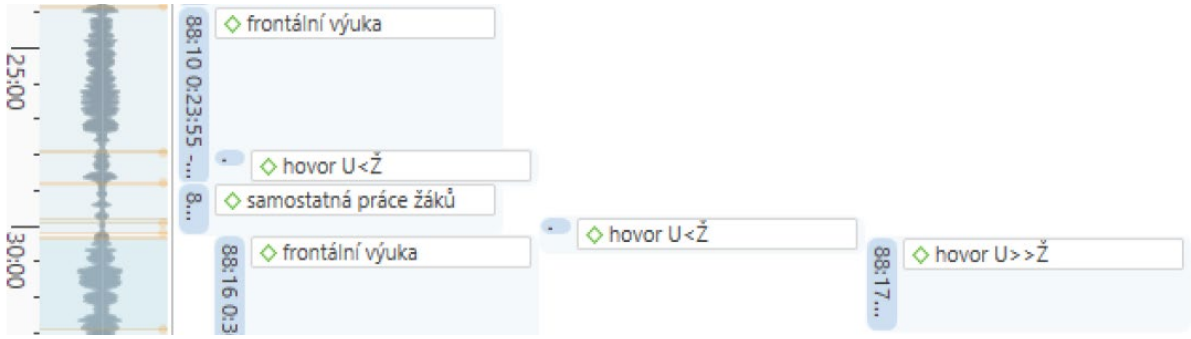

Figure 2: Atlas.ti programme

The lessons were described in detail with a focus on the teacher's activities, and at the same time these lessons were coded and annotated. Multi-level codes were used for videos where individual phenomena were classified or categorized. The results were then compared with the attitudes that teachers declared in semi-structured interviews

The default codes were created by analysing several videos from each teacher by the three authors of this paper. Some codes were pre-designed, some were created during the initial analysis, others were created during the detailed analysis of other lessons. A total of 46 codes were created and used. These were divided into 9 categories:

- 1. Pupil's activity on PC or laptop
- 2. Teacher's activities
- 3. Forms of instruction
- 4. Phenomena in teaching using ICT
- 5. Used programmes and applications
- 6. Teacher-pupil communication

- 7. Pupil's activities at the blackboard
- 8. ICT involvement
- 9. Testing

Codes were used in the total of 722 cases and indicated not only the occurrence of a phenomenon but also the time of its duration (a total of 591 time periods were marked).

4. Results

4.1 Characteristics of the teachers

Let us first present the characteristics of the observed teachers. They show that in all three cases they are very experienced teachers with good knowledge of computer technology. All three actively attend in-service teacher training. They work at various schools in different towns in the Czech Republic.

4.1.1 Rudolf

Rudolf has been teaching for about 15 years. He studied mathematics, physics and computer science. He currently teaches computer science and works as a network administrator at his school. He now teaches mathematics less and only to older pupils. On average, he attends in-service training courses for teachers of mathematics or computer science once a year (the last one focused on GeoGebra). Rudolf claims to be rather sceptical about the use of technology in teaching. The school management does not put too much pressure on teachers to use technology in teaching or in other areas.

Rudolf teaches in a classroom equipped with a computer and a data projector that he uses in all of his lessons. He cannot teach in a computer lab and does not have the opportunity to use an interactive whiteboard.

4.1.2 Petr

Petr has been teaching for 43 years. From the beginning of his career he has been teaching mathematics. His study fields were mathematics and technology for lower secondary schools. He has been the school headmaster for twenty years. Petr attends various seminars very often, usually at least once a month, and is a lecturer of SMART interactive whiteboards. He thinks that modern technology can help pupils develop their imagination. As the headmaster, he made the decision to replace traditional whiteboards with interactive ones.

In his lessons, Petr only uses interactive whiteboard, he does not teach in a computer lab, nor does he have computers available for individual pupils.

4.1.3 Jana

Jana has been teaching for 26 years and has been teaching mathematics and chemistry since the beginning of her career. She is currently the Deputy Headmistress. According to Jana, effective teaching means that the teacher should speak as little as possible in the lessons. Then pupils learn from each other and the teaching is more of a dialogue than mere frontal teaching. Her point of view of technology in the classroom is that it is a helper. She regards herself as a pioneer as she has one lesson of math a week with tablets. With one of her classes that is smaller, they go to the computer lab to practice. A number of programmes for practicing mathematics are installed there.

Jana has her classroom equipped with an interactive whiteboard, she can use a notebook and can have her lessons in the computer lab.

4.2 Extent of the use of ICT in lessons

The first information about the use of ICT in lessons can be found in an overview of the time for which two basic technologies were used in the lessons – the interactive whiteboard and the data projector (see Figure 2). This overview shows that Rudolf used a computer in the lessons least. He did not have an interactive whiteboard in the classroom and turned on the data projector in less than half of the lessons.

On the other hand, Petr, who did not have an ordinary whiteboard in the classroom, used the interactive whiteboard in all of his lessons. There was no situation in which he would only turn on the beamer without using the interactive whiteboard. Jana combined both technologies in her lessons. In most of her lessons, the use of interactive whiteboard dominated. In two cases, she used both the interactive whiteboard and the data projector without the interactive whiteboard in the lesson. However, there were also two lessons in which she used only the data projector and did not turn on the interactive whiteboard.

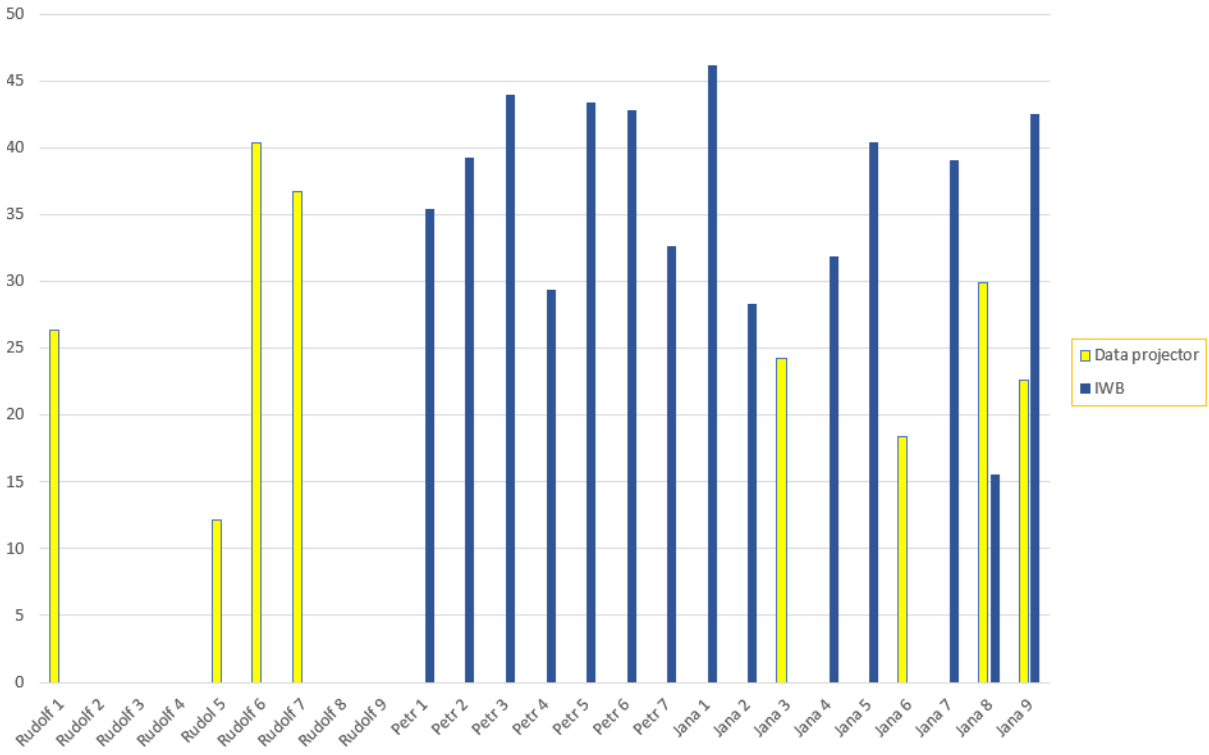

Figure 2: Comparison of data projector and IWB usage

If we focus on the use of the IWB, which is the most commonly used tool in Petr's and Jana's lessons, we must look at how both teachers work with IWB in their lessons. These observations will be treated in separate subchapters.

4.2.1 Petr's lessons

Observations from Petr's lessons show great homogeneity. Frontal teaching predominates in his teaching. Although he tries to interact with pupils, he is in most cases limited to one-word or very short answers to the questions asked.

The IWB is primarily used as an ordinary whiteboard. He uses it with high user confidence. In the analysis of the records from the lessons, we could observe times when, if necessary, he also makes use of functions that differentiate the IWB from an ordinary whiteboard – these are mainly moving of parts of texts (drag and drop) and their formatting or return to the "already deleted whiteboard". He often uses interactive tools that are part of the software that comes with the board. In several lessons he works with the interactive calculator. If necessary, he also uses an interactive whiteboard to project a picture from the visualizer (see Figure 3).

If we look at the applications he uses in his lessons, we can see the use of the GeoGebra programme, both on the side of the teacher and his pupils in their mobile devices (see Figure 4).

4.2.2 Jana's lessons

Jana's teaching was very diverse. Once a week, she taught in a computer lab. Even in her case, frontal teaching dominated. However, she included various activities in her teaching in which the way of communication changed. As the only one of the observed teachers, she used pupils' group work. In her class, Jana combined writing on a whiteboard, flipchart, interactive whiteboard and a projector. We can see diversity also in the

overview of applications that she used in her teaching. While in Petr's case, the use of SMART Notebook was predominant, Jana, although IWB was also used for writing, predominantly uses other applications (see Figure 5).

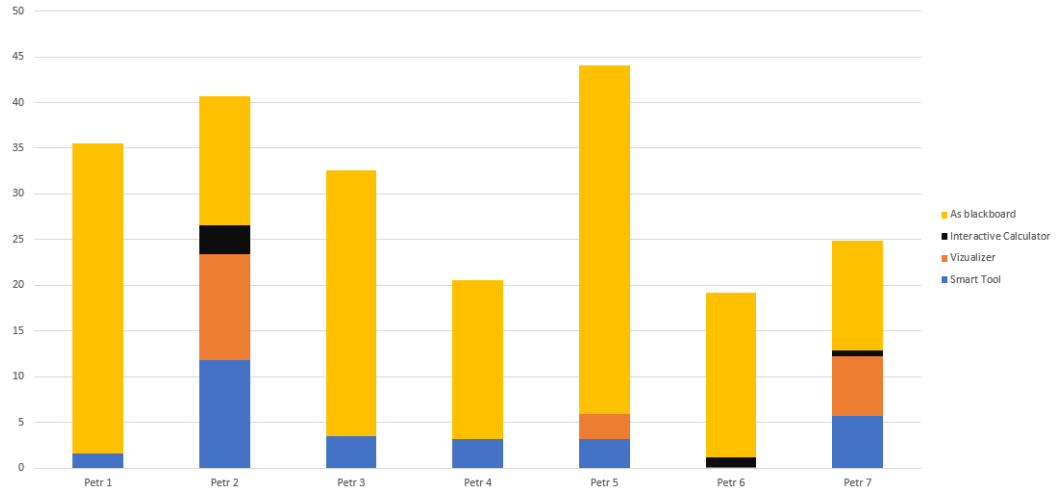

Figure 3: Use of IWB in Petr's hours

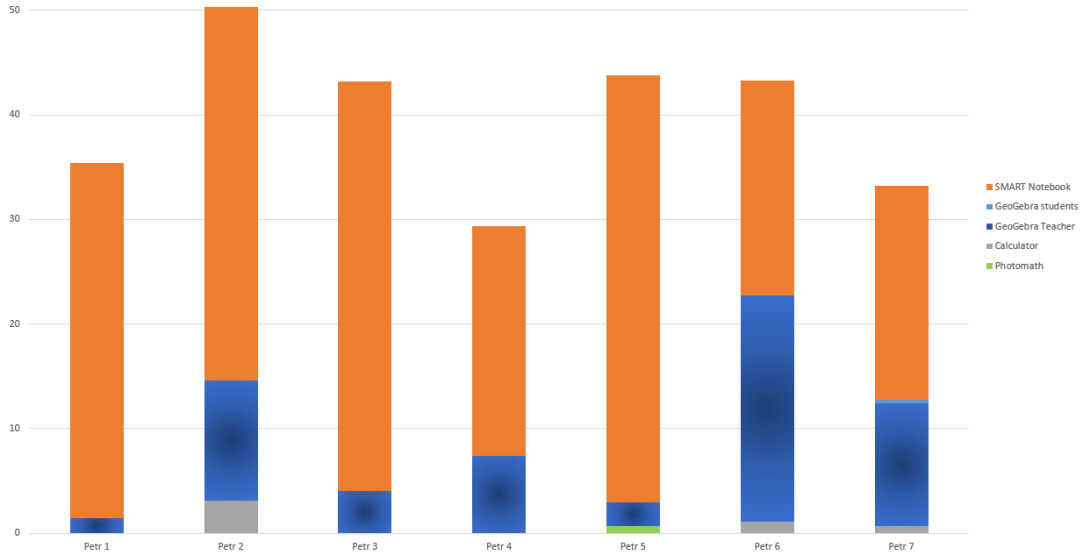

Figure 4: Use of software in Petr's lessons

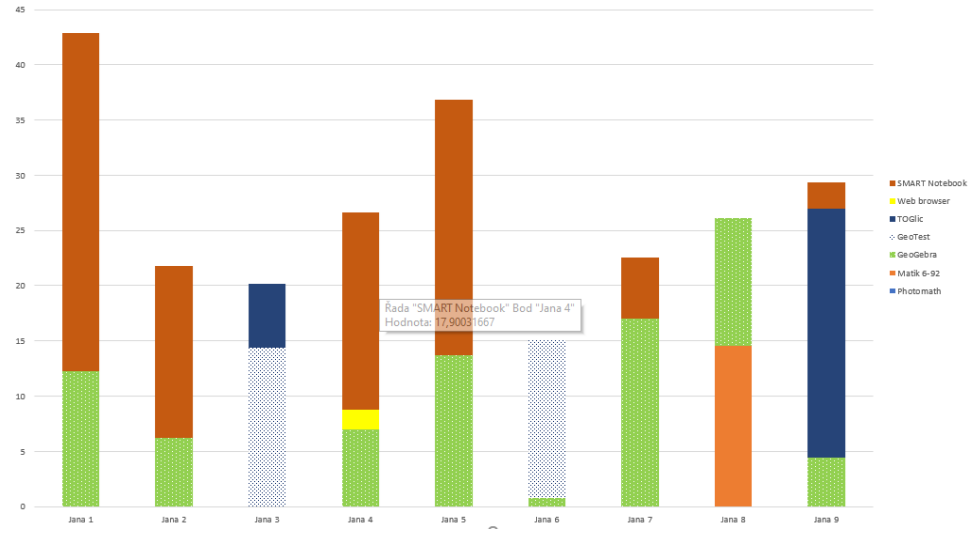

Figure 5: Use of software in Jana's lessons

5. Conclusion

The study, whose partial results are presented in this paper, confirms that the teacher's beliefs in all the observed cases significantly affect the way the teacher actually uses technology in teaching. Rudolf's beliefs led to the fact that he did not perceive modern technologies as helpful with respect to epistemology and therefore he did not include them in this topic.

Petr was, on the one hand, not convinced that modern technology really helped pupils more than traditional teaching without technology, but at the same time believed that the dynamism of GeoGebra could make it easier for pupils to understand. These seemingly conflicting views explain Petr's use of the interactive whiteboard most of the time as a whiteboard, with the exception of dynamic models created in GeoGebra when he used its interactivity.

Jana's beliefs were related to the fact that dynamism can make it easier for pupils to understand the topic, to the belief they need drill, and to the fact that pupils' independent control of programmes leads to more precision. This was reflected in particular in the fact that Jana was the only one to lead the pupils to independent use of modern technologies. However, the pupils used technology exclusively for practice.

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