EXPLORING AND DISCOVERING INFORMATICS -
AN EXAMPLE OF TEACHING INFORMATICS IN PRIMARY SCHOOLS

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Abstract

Informatics occupies a central place in today's society. With its modern technologies, a society without Informatics would be unimaginable. Nevertheless, the subject of Informatics still plays a minor role or is neglected altogether in many schools - especially in primary schools. The aim of this paper, therefore, is to try to break the trend of regarding Informatics as negligible with the help of the new, interdisciplinary research area of neurodidactics. The paper aims at illustrating the importance and practicability of Informatics education in primary schools considering neurodidactical concepts and principles. It describes the project *Exploring and discovering Informatics* carried out during the last school year in the 3rd and 4th grade of a Carinthian primary school. The project was funded by the teacher support program *Informatik kreativ unterrichten* (Teaching Informatics creatively), a regional part of the Austrian teacher support system IMST[1] that aims at strengthening MINDT[2] education in Austrian schools.

Overall, the project *Exploring and discovering Informatics* concentrates on teaching a first understanding of important concepts of Informatics awakening the students' curiosity and on developing a modern education that prepares the children for their further way of (school) life, which is almost unimaginably without Informatics today.

After describing the project including some teaching units based on neurodidactical principles this paper reports on the promising results of the final evaluation.

Keywords: Innovation, technology, research projects.

1 INTRODUCTION

Nowadays, children grow up in a changed, engineered living environment. The school's task is to react to it and not to ignore this new world, as they did before. Often, this notion of ignorance was not due to the school's engagement, but the result of missing competences of teachers, which could have been compensated by university consultations by now. The earlier children come in contact with technology or informatics the better. As we know from neuroscience this is also possible because the capability of abstract thinking and basic technological skills are already developed at pre-school age [1].

Some approaches like *Informatik erLeben* (Experiencing Informatics) [2] or *cs4fn - Computer Science For Fun* [3] have shown in practice that core topics of computer science can easily be taught in primary school at an adequate level. But the success declines with the age of the students. This underlines the importance of such initiatives already at an early age. The children's attitude towards technology and informatics (often considered as "difficult") can be influenced positively and fears, which are often observed in secondary school students and adults, can perhaps be avoided [1, 2].

Interest for technics and new developments definitely exists in primary schools and should be promoted as well. Especially the girls' interest for technical subjects like Informatics should be stimulated, as they were often neglected in respect of technics so far. Creative school projects, e.g. those within the teacher support program of *Informatik kreativ unterrichten* (Teaching Informatics creatively), a regional part of the Austrian support system IMST, may be a good start to introduce Informatics in primary schools. Certainly, they have to be appropriate for children. The proposals and principles of neurodidactics can help to develop teaching material and lessons that are suitable for the brain of young children and their way of learning. One example is the project *Exploring and discovering Informatics* that was carried out within the support program of *Informatik kreativ unterrichten* and as a part of a diploma thesis about neurodidactics in practice [4]. The project and its evaluation are described in this paper.

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[1] IMST – **I**nnovations **M**ake **S**chools **T**op
[2] MINDT – **M**athematics, **I**nformatics, **N**atural Sciences, German (**D**eutsch) and **T**echnology

2 THE PROJECT 'EXPLORING AND DISCOVERING INFORMATICS'

2.1 Motivation And Background

Informatics occupies a central place in today's society and the school's task is to react to it in order to teach the children a responsible handling with technology and Internet. As already mentioned above technology and informatics should be introduced as early as possible, certainly in a child-oriented and playful way by considering how the brain works.

One successful and also brain-based approach focusing on a Computer Science education is *Informatik erLeben* (Experiencing Informatics) [2]. It comprises a collection of various teaching units on Computer Science education. The aim of these units is to show adolescents that technics in general and Informatics in particular are worth thinking about, via an exemplary choice of topics in Informatics. Informatics should be 'experienced' by the students, and they should understand how computer processes and procedures really work. Furthermore, they should realize the general principles that are behind these processes, and how they could be meaningfully used outside of the studies of Informatics. Adolescents as well as younger students (from primary school upwards) ought to slip into the role of data, computer components or programming parts in order to experience the computer in a playful way and understand the main concepts and principles better. However, it is not merely about conveying proficiencies but more about conveying a subjacent understanding and comprehension of the most important principles of Computer Science, and aims to arouse the students' interest and curiosity for this future-oriented subject [2].

The methods used in *Informatik erLeben* contain some elements and principles proposed by neurodidactics [5]. It is of great importance to use appropriate teaching methods that consider how the brain works (e.g. discovery learning, learning by doing, learning by teaching, etc. [6]) where the learner can be actively involved in the learning process, can exchange experiences and knowledge with colleagues and where different sensory inputs are provided, in order to simplify the comprehension of complex ideas. Students might have a lot more problems to understand concepts like encryption mechanisms in a mainly teacher-centered education where they just have to listen and reply. Especially with topics like encryption or the binary system, students need various options to 'discover' the topic on their own or with the help of a partner in group work. Galileo Galilei (1564-1642) perfectly described this phenomenon with the following words: "We cannot teach people anything; we can only help them discover it within themselves."

However, it is not enough that teachers are informed about the importance of brain-based learning strategies. It is also necessary to implement them into the education system, e.g. by accomplishing projects like those of the regional teacher support program *Informatik kreativ unterrichten* (Teaching Informatics creatively). This program is funded by the Carinthian Economic Promotion Fund and part of the Austrian support system IMST that wants to establish an innovative culture in order to strengthen MINDT education in schools [8]. The project *Exploring and Discovering Informatics* is one example of the regional program *Informatik kreativ unterrichten*, which funds creative informatics projects in primary and secondary schools.

Exploring and Discovering Informatics is partially based on *Informatik erLeben* and was initiated by two teachers of a primary school in Klagenfurt with the help of a student of the University of Klagenfurt. The school targets to emphasize 'exploring and discovering' and wants to integrate Informatics lessons into the classes in order to realize a modern education. The initialization of a project like this could therefore be seen as the starting point of a new, reformed primary education. Moreover, the two teachers aspired to encourage cooperation between universities and schools and to generate the attached transfer of knowledge. With such cooperation, useful insights can be exchanged and the schools and teachers, respectively, get support from university consultation. Cooperation is therefore in the center of attention.

Overall, the project concentrates on teaching a first understanding of important concepts of Computer Science, awakening the students' curiosity and on developing a modern education that prepares the children for their further way of (school) life, which is almost unimaginably without Informatics today.

2.2 School And Project Participants

The project has been carried out in two classes – a third and a fourth grade – of the primary school 9 in Klagenfurt. In the third form, there are 14 girls and 8 boys between eight and nine years. According to the school's coach, the students' parents fostered their access to modern technologies quite early.

Similarly, in the fourth class, which consists of 8 girls and 13 boys, all between nine and ten years, parents cater for an encouraging environment for technics at home as well. The children already have access to new media, but still have to learn quite a lot about a careful and responsible handling.

The third, as well as the fourth form, are Everyday English classes. This means that they already gained some fundamental language skills in English, which might be beneficial considering the widespread use of English terms in the area of Informatics. In general, both classes are very interested and open to new experiences, which could be credited to the teachers' engagement and way of teaching-management. For them it is very important to preserve the students' interests and to support and promote them as much as possible.

2.3 The Goals

The general goal for this project is to teach first principles and concepts of Informatics in a playful, child- and brain-based way. Students, however, should not only learn for their further career, but should already make use of the new knowledge in primary school education. They shall:

- learn how to handle devices (hard- and software) and the Internet in a responsible way;
- get to know the computer as a useful tool for creating simple text- and picture-documents;
- foster their creativity, cross-linked and logical thinking;
- playfully get to know different topics of Informatics with consideration to their everyday lives (e.g. coding, binary-system, encryption).

Furthermore, the general interest for Informatics and the comprehension of the new concepts is observed in order to filter out significant differences between boys and girls.

Not only students but also teachers and the school shall benefit from this project. Teachers can

- acquire new skills in the course of advanced training;
- get to know appropriate topics in Informatics, which can be used for their teaching lessons;
- get to know a child-based usage of computers;
- learn how to create teaching materials, like learning games, with the help of a computer.

As the evaluation shows Informatics education should definitely be taken into consideration already in primary schools and should be regarded as meaningful and positive.

2.4 The Project Implementation

2.4.1 The Proceeding

The project was carried out at a regular interval of 14 days, always in units of 100 minutes per class. Playfully, and by considering neurodidactical principles, basic concepts of Computer Science were explained and partially acquired by the students themselves. Group work, self-organized exploring and discovering, cooperative learning concepts, as well as Informatics lessons without computers are focal points here. Therefore, the aim of the project is to move away from a teacher-centered education to a learner-centered one.

Before starting with the actual topics of Informatics, it was necessary to familiarize the students with the new situation and the project. The first lesson was used as an introductory unit with the purpose of getting to know each other and giving an overview of the project's aim and content. Subsequently, the students were asked to fill in a questionnaire, which examined their current state of knowledge, as well as their access to new media. First and foremost, it was necessary to determine whether the kids had access to new technologies at home, which experiences they had already gained and how much time they usually invested in these technologies. By finally asking them about their understanding of the term *Informatics*, their previous knowledge was tested. The primary goal here was that every student should be able to generate an idea of the term Informatics and define it in his or her own words at the end of the project. The evaluation and interpretation of this questionnaire can be found in 3.2.

The two teachers' wish was to show students a respectful and responsible handling of computers. As the primary school is not equipped with enough computers (every class has only one), the University

of Klagenfurt offered five Laptops for this special purpose. Together with another laptop, which was purchased from the project's budget, each group had seven devices to work with.

Apart from the Informatics lessons at school, the students also had the chance to gain more experience in the area of Informatics by visiting the University of Klagenfurt. Together with the teachers, they were allowed to attend a special children's lecture. Basically, it was a regular lecture scheduled for university students, which had slightly been adjusted concerning pace, terminology and comprehensibility. The lecture is called Introduction to Informatics and provides an overview of the most important topics in Informatics, such as: definition of Informatics; coding and information, computer architecture, software, computer peripherals, operating systems, computer networks and the history of Informatics. The topic for this special unit was storage media, where different media types were passed around through the rows and could be explored by the students themselves.

Moreover, the students experienced a guided tour through the huge university library and got access to the libraries treasure chamber, where precious and extraordinary books are kept. Besides inspecting the university itself, the aim of this visit was to gain a first impression of a 'real' Informatics lecture and to arouse the students' interest for the studies of Computer Science.

2.4.2 The Teaching Units

The topics that should be introduced in the two primary school classes were chosen together with the teachers. As mentioned above the project *Exploring and Discovering Informatics* is partially based on *Informatik erLeben* [2] but also new units were developed and introduced. The existing units of *Informatik erLeben* (Hardware and Encryption) were also slightly adapted and completed with some material.

2.4.2.1 Hardware Unit

Basically, most of the teaching units in class were based on *Informatik erLeben*. Quite a lot of time was spent on computer hardware. Thus, the project actually started with an *Informatik erLeben* unit named *E-H1: Hardware Fundamental* [2], which was slightly adapted and extended. This unit is primarily designed for primary school students, as it does not require previous knowledge. The unit focuses on active and explorative learning, where students slip into the role of hardware components and try to understand how the single parts of a computer work together and process information. The picture below should help to demonstrate this procedure.

Figure 1: Slipping into the Role of a Computer – 3rd grade

Apart from the flashcards, real hardware components were shown to support a better comprehension. The students were absolutely fascinated by the small and filigree components, and almost could not imagine that such a tiny processor really processes all the information in a computer system.

In order to strengthen the retention of the new input, the third class also created a special *Hardware-Memory Game*. Instead of the common Memory rules, where the players have to search for two appropriate pictures, new 'rules' were developed. Not two pictures have to be found, but a picture and its appropriate written explanation. An example is provided in Figure 2, which shows two different Memory pairs created by the students.

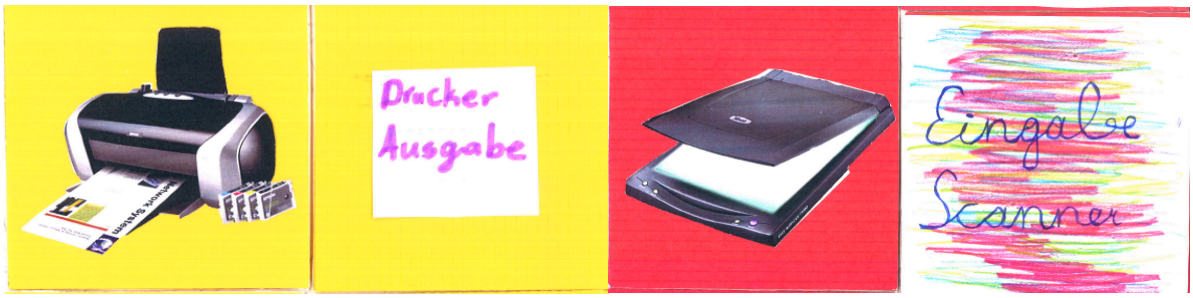

Figure 2: Hardware Memory Game

Although the process of manufacturing a Memory game takes quite a while, it is not a waste of time. Students do not only learn whilst playing the game, they also do so during the kinematic process of creation. In groups of five to six people, they had to come up with the definitions and explanations on their own and create appropriate Memory cards. In this way, four individual and colorful Memories were created. Of course, upon completion the students had some time to play the game and solidify their newly gained knowledge.

2.4.2.2 Encryption Unit

Another topic that was dealt with in the two classes was *Encryption*. Again, the basis for this double-lesson was provided by Bischof and Mittermeir and one of their *Informatik erLeben* units i.e. *V1- Encryption with the Caesar-cipher* [2]. Although it sounds quite difficult to introduce the principles of encryption to primary school students, it can easily be conveyed with the help of associations from every-day life, some quickly created turntables, flash cards of the alphabet, and the appropriate teaching unit provided by *Informatik erLeben*. This teaching unit suggests attracting the students' attention by showing them a cryptograph right at the beginning of a lesson, without telling them what the whole lesson is all about. Students tend to be curious and are eager to solve the riddle. After some guesses, the cryptograph should be slowly decoded together with the kids. Of course, it is important to start with a very simple encryption mechanism, such as mirror writing, and gently lead over to more complex strategies like the Caesar cipher. For mirror writings and encryptions with the Caesar cipher, flash cards of the alphabet - in two versions of different colors e.g. green and red - can be used. The cards are simply placed on the floor. The first version should be placed there in the correct alphabetical order. The second row can then either be placed in the mirrored order for mirror writings, or shifted with a certain key for the Caesar cipher. Figure 3 clearly depicts how the flash cards can be used. Here the students try to decrypt a code in mirror writing.

Figure 3: Decrypting code

2.4.2.3 Laptop Units

Apart from theoretical concepts of Computer Science, the students should also get a feeling for the handling of standard software programs, e.g. text editing or presentation programs. For this purpose, two different teaching units were established. The first one focused on the usage of USB memory sticks and text documents, whereas the other unit intended to improve the students' presentation skills with the help of Microsoft PowerPoint.

First of all, the students were divided into groups of three and were provided with a laptop and a USB flash drive where they could find the beginning of a story from a children's book. Each group got a different story, though. The students' task was to plug in the USB flash drive, open the text document with the beginning of the story, continue the story by adding a few sentences, store the document, correctly unplug the drive and pass it on to their neighboring group. The neighboring group, which received the new data medium then started the whole process anew. This process should be repeated until every group accessed every USB drive (there were seven in total) and the different stories came to an end. The students were asked to work and organize themselves in groups, though some

instructions from the teacher were necessary too, as a trial and error strategy can lead to problems when USB memory sticks are inappropriately handled (e.g. data loss). Since the teaching resources were limited (no projector, no teacher's computer), the main steps how to use a USB flash drive were explained orally or illustrated at the blackboard. In case students needed more precise explanations or help with anything else, the teacher was always there to give advice.

By implementing such a procedure, the students learn and practice the use of USB flash drives and text editors, promote their creativity and the ability to work in teams and create wonderful short stories in groups. Moreover, this method does not only imply neurodidactical concepts and principles - it is an interdisciplinary unit as it fosters the students' writing skills as well.

The second laptop unit was about creating PowerPoint presentations with the help of learning videos. The students were asked to develop a short overview of the Informatics topics dealt with during the project. By doing so, they could reflect on their experiences and impressions, and repeat and foster the newly gained skills. A detailed description, as well as the evaluation of this particular teaching unit, which is based on COOL concepts, can be found in chapter 2.

2.4.2.4 PowerPoint

Within the project and a diploma thesis a teaching unit about PowerPoint for very young learners of primary schools (3rd and 4th grade) was developed and evaluated [4]. The general assumption is that these students are beginners, who are not familiar with standard software, but at least know how to handle a computer mouse and the keyboard. Instead of simply showing students how this application works, with the help of a projector and the principal of 'I click then you click', the students get the task to discover the tool by themselves. For this purpose, they are provided with a worksheet, which explains the main steps of what they are supposed to do, and learning videos.

In a first step the students are divided in groups of two to three people and together they had to create a PowerPoint presentation on what they have learned in the Informatics lessons so far. Each group should consist of one girl plus two boys, or vice-versa, and at least one student, who serves as the 'expert'. The 'expert' can share his or her previous knowledge with the other group members, even though this knowledge is not on PowerPoint but on the general handling of computers, which can be beneficial as well, as some students even had problems to correctly use a computer mouse. The teacher slips into the role of a coach or consulter, who only provides the students with the necessary requirements: technical requirements (computer, software, memory sticks.), the worksheets and of course the learning videos. In case they need help they are supposed to watch the videos, which describe the proper handling of PowerPoint step-by-step. However, the videos only show the basics of PowerPoint but do not answer textual or stylistic questions. The students need to be creative, work independently in groups and create individual presentations.

Although the task was to independently work in groups with the help of the learning videos, some instructions from the teacher and from the work sheet, the first questions occurred even before they had managed to open one of the files from their USB-sticks. However, instead of answering all of them, they were requested to make use of the provided material first and try to solve the problems on their own (except technical problems and problems that could not be answered with the provided resources).

During this whole process of creating individual presentations, the teacher's task was to support and 'coach' the students. We tried to control and observe the proceedings and walked from group to group to make sure that the students were on the right track and helped them by giving some advice or clues on how they could improve their presentations.

Of course, it is also useful to present PowerPoint presentations. Besides the fact that it is a good practice, students get the chance to be proud of what they created and share these positive emotions with their colleagues. Although there might have been enough time for presentations at the end of the four lessons, we decided to arrange a presenting afternoon, where both classes come together and present their individual overview of the Informatics lessons and their experiences. The spare time could be perfectly used for reflections and feedback.

3 EVALUATION AND RESULTS

3.1 Research Questions

As already outlined in the introduction, the project aims at investigating the importance and practicability of brain-based Informatics in primary schools. The research questions stated in this chapter emerged in the course of the project, and their answers should provide information on the importance and practicability of brain-based teaching of Informatics.

- Are factors, which emphasize the importance of Informatics education, like interest in Informatics, use of new media, and comprehension of the term Informatics, already given in primary schools?
- Is it possible to teach first concepts and principles of Informatics in primary schools without any drawbacks?
- Do projects like *Exploring and Discovering Informatics* help to simplify and support the implementation of Informatics education?
- Does brain-based learning positively contribute to the practicability of Informatics and will teachers be able to adopt neurodidactical education in the future?
- Are boys and girls equally qualified for and interested in Informatics?

The answers to these research questions were developed through the evaluation of questionnaires, observations and feedback from the teachers and are presented in 3.2. Altogether, the students answered three different questionnaires. The first one was an introductory questionnaire that examined the students' experiences with computers and the Internet - generally speaking, their previous knowledge on Informatics. The second questionnaire, which was handed-out at the end of the project, dealt with brain-based material and the students' general attitudes towards brain-based concepts and the project itself. Finally, they answered some questions focusing on Informatics, which sought to determine how students evaluate their own Informatics skills, and whether their attitudes towards Informatics had changed after the implementation of the project.

The second method of evaluation is a written feedback obtained from the two teachers of the third and fourth form. Originally, a short interview with the teachers was planned, but the teachers preferred a written statement, because of their shortage of time. They were thus provided with the actual interview questions, which they briefly answered in a written statement, giving some interesting insights in and reflections on the project.

3.2 Results

The results derived from these methods, however, cannot be regarded as universally valid. The project was carried out in one specific primary school in two different classes. Therefore, only opinions, experiences and results from the students and teachers of this school were taken into consideration. Other schools might come to other solutions and outcomes. Nevertheless, these evaluations offer an interesting insight in at least one primary school and could encourage other schools to re-evaluate their teaching methods and curricula as well.

Are factors, which emphasize the importance of Informatics education, like interest in Informatics, use of new media and comprehension of the term Informatics, already given in primary schools?

On the basis of the findings from above, this question can definitely be answered with a 'yes'. The results from the questionnaires clearly highlighted the students' interest in Informatics and show that even very young learners have a lot of contact with the new media and technologies at home, already.

Is it possible to teach first concepts and principles of Informatics in primary schools without any drawbacks?

It is indeed possible to teach first concepts and principles of Informatics in primary schools, though sometimes a few problems may occur. Judging by the experiences that were acquired in the course of this project, it could be said that students find playful, brain-based Informatics lessons appealing. They obviously enjoy varied teaching methods were they were actively involved in the learning process, but are also very interested in topics about Informatics in general. Furthermore, the topics dealt with in

class were very well adjusted to the students' knowledge level, and they obviously had no problems to comprehend the themes and get a first idea of Informatics concepts.

Nevertheless, the findings from above also show that there might be some drawbacks when teaching Informatics in primary schools. These disadvantages, however, do not relate to the students' abilities, but to the teachers. The teachers frequently mentioned not to be able to teach those Informatics topics on their own, as they are not computer literate and are not familiar with the terms and principles which are necessary to teach the subject of Informatics. The teachers were probably just a bit too skeptical and afraid of making mistakes. With the help of prepared teaching units, like those from the *Informatik erLeben* website [2], and a bit more self-esteem and effort, teaching first concepts and principles of Informatics could be easily implemented without any difficulties.

Do projects like *Exploring and Discovering Informatics* help to simplify and support the implementation of Informatics education?

The results from the evaluation show that projects like *Exploring and Discovering Informatics* do help to simplify and support the implementation of Informatics education. The students had the possibility to gain first insights and experiences in the field of Informatics, and although many students were already interested in Informatics before the project, for some of them the project was necessary to arouse their interest, to develop a certain understanding of the subject and to get an idea of what Informatics is actually all about.

However, the teachers, especially, needed to be motivated and encouraged to implement Informatics lessons at school, which could be partially achieved by carrying out a project like this, where an external person from university came to implement the teaching units. In this way, the teachers get the opportunity to observe someone else teaching Informatics, before they try it out on their own. Furthermore, the teachers may acquire new skills and get to know appropriate topics in Informatics, which can be used for their teaching lessons as well. Although the teachers did not explicitly state why they have not implemented Informatics lessons so far, an undeniable uncertainty and strong demand regarding appropriate topics on Informatics could be observed in the course of the project. Implementing projects like *Exploring and Discovering Informatics* can definitely help to encourage teachers by providing appropriate teaching materials and topics, and by showing them how easy it can be to teach Informatics to primary school students even if one is not an expert in the field.

Does brain-based learning positively contribute to the practicability of Informatics and will teachers be able to adopt neurodidactical education in the future?

The first part of this question can be answered with a simple 'yes', whereas the second part of the question demands a more complex answer. Besides the fact that most students obviously enjoyed the new brain-based teaching methods, neurodidactical concepts also helped to achieve a better understanding of the topics that were dealt with in class. According to the teachers' written feedback it is not certain how much of the neurodidactical concepts they will be able to adopt in the future. Although they promised to apply some of the topics, these themes will mainly relate to the use of computers and USB memory sticks, but not to neurodidactical education strategies - apart from implementing new projects or intensifying group work.

Are boys and girls equally qualified for and interested in Informatics?

According to the results of the questionnaires, boys and girls are more or less equally qualified for and interested in Informatics. The evaluation of the third questionnaire showed that there are only slight differences between boys and girls. The answers from boys and girls to questions like 'Are you interested in Informatics?' or 'Are you well-suited for Informatics?' only differ insofar as boys were more likely to tick 'yes', whereas girls tended to respond with a 'rather yes'. Moreover, more girls wished for more detailed instructions during the teaching units than boys. Although the students do not really perceive differences between boys and girls concerning the suitability for Informatics, the assessment of their own interest and suitability shows that boys are slightly more interested in and qualified for Informatics than girls.

Concerning my own observations during the project, it is quite difficult to answer this question properly. There was probably not enough time to determine differences between boys and girls and their interest and abilities in Informatics. The only thing that is worth mentioning is that it was easier to whip up enthusiasm in boys than in girls, which could signify a tendency that boys might be slightly more fascinated by this subject. However, both boys and girls seemed to be very motivated and interested in the various topics of Informatics and managed to solve the tasks equally well without serious difficulties.

4 CONCLUSION

Summing up the main aspects of this project, it could be said that Informatics education can and should be introduced as early as primary school, though with the precondition of creating child-oriented, playful and above all, brain-based lessons. In order to encourage teachers to integrate Informatics education into the actual curriculum, they need to be supported and strengthened in their ability to implement Informatics even if they are not experts. One way of doing this has already been provided by Bischof and Mittermeir [2], who developed appropriate, ready-to-implement teaching units, which can be easily applied and transferred to primary schools. Another fantastic way to simplify and support the implementation of Informatics education into primary schools is offered by IMST, which develops encouraging, interesting and supportive projects like *Exploring and Discovering Informatics*.

Hopefully, the results of this project provided new input and thoughts about the importance of the implementation of brain-based Informatics in primary schools. Young students are already interested in Informatics and are just waiting for enthusiastic teachers who are willing to change their old way of teaching and adjust it to modern, brain-based education methods that highly support the students' learning progress, and try to get over doubts and uncertainties in order to be able to implement the modern subject of Informatics.

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