A Congress for Children and Computational Thinking for Everyone

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ABSTRACT

As final event of the project "Informatics – A Child's Play?!", which aimed at introducing computational thinking in primary and secondary schools, the authors initiated the first Children's Congress in 2016 with the main theme of "Languages – Pictures – Information". This is now an annual event, where all participating children can slip into the role of researchers and present the results of their projects accomplished together with their teachers as well as teacher students of different master courses. As preparation the project teams get an introduction into computational thinking and several computer science concepts with the task of applying at least one of them in their project and the development of creative products. The themes of the Children's Congress are relatively open and fit into every subject, because our main aim is introducing computational thinking "by the way" to all participants. During their work on cross-curricular or even subject specific projects, pupils, students and teachers learn that basics of computational thinking are or can be integrated in every subject. This paper reports on the implementation and procedure of the Children's Congress and gives an overview of the projects accomplished in the first two years (2016 and 2017). It describes how and where computational thinking has been integrated and presents the main results of the evaluation gained from interviews and questionnaires.

CCS CONCEPTS

• **Social and professional topics → Professional topics; Computing education;** *K-12 education*

KEYWORDS

Computational Thinking, Digital Literacy, Competition, Children as researchers, Teacher training

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1 INTRODUCTION

Since Wing's paper in 2006 [18] computational thinking (CT) as problem-solving process is seen as "fundamental skill for everyone" and many extra-curricular initiatives have been lanced in order to integrate it into primary and secondary education. Experts point out the importance of introducing children to CT concepts early on in school and in the meantime computational thinking has also found its way into the curricula of several countries. This increases the demand for in-service training, as many teachers did not learn about CT in their initial education. [6] These arguments led to our research project "Informatics- A Child's Play?!", directed to children of primary and lower secondary school (grades 1-8) as well as to their teachers. This project aims at teaching basic concepts of computer science and mainly computational thinking as "the use of computer science concepts to solve a problem in any domain" [18] As final event of the project, the Children's Congress was implemented for the first time in 2016 in order to give the young participants the possibility to slip into the role of researchers and present their work. In the mainly cross-curricular school projects they accomplished during their regular lessons in different subjects, they had to apply at least one computer science or computational thinking concept and to create (digital) products. Whereas teachers and pupils mainly concentrated on the thematic focus of the congress (e.g. languages), our aim was, and still is, to build awareness on computational thinking and connecting it to topics and contexts of everyday life. In this way we want to increase interest in informatics, correct possible misconceptions and work against still existing fears and inhibitions concerning computer science and technology. We further want to make children curious and give them a first insight into the work of researchers, which may also contribute to their scientific literacy, usually an important aim of science education [7,9]. Whereas science educators and researchers claim scientific literacy for all [10], we follow the demand of Jeannette Wing [18] providing computational thinking for everyone. Hence, we do not address only children and teachers, but also prospective teachers, master students of teacher education programs, who shall gain additional teaching experiences during their studies. This form of project-based learning is something new and brings benefits for all target groups beyond computational thinking.

Due to the success of the first congress and with the aim of integrating computational thinking sustainably in primary and secondary education, the Children's Congress is now organized every year. This paper describes the concept and implementation of the Children's Congress as well as the included computational thinking contents. It further reports on the evaluation results of the first two congresses in 2016 and 2017 gained from interviews and questionnaires as well as from the analysis of the presented school projects regarding the inclusion and application of computational thinking.

2 Related work

Various initiatives aim at introducing computational thinking in the classroom, be it on curricular [1,2,16] or extra-curricular level (e.g. [4,5,17]) or in teacher education [3,19]. Computational thinking is defined as problem solving process [16] and "the use of computer science concepts to solve a problem in any domain" [18]. For teaching computational thinking in primary and lower secondary school, where related subjects and computer science teachers are missing, it is necessary to connect it to the contents of other subjects. Teachers firstly have to be convinced, that teaching computational thinking respectively main concepts of computer science is possible even in elementary and primary education, as proved e.g. by Schwill [15]. However, computational thinking is not programming. The main idea behind is that children learn to think and solve problems and, as also mentionned by Rees at al. [13], "develop stronger mental models that ultimately make them better software engineers". Teachers without informatics background need concrete examples of where and how they can use which computer science concepts. Hence, our main work before starting the project "Informatics – A Child's Play?!" was a curriculum analysis in order to make visible how much computational thinking is practiced unconsciously already in primary education. As result we connected many key concepts and activities of computer science to typical activities of primary school. [14]

However, for a successful and sustainable implementation of computational thinking at school it is not enough offering single (extra-curricular) initiatives for pupils (e.g. the Bebras contest [8]) and lancing new curricula. With the implementation of the new Austrian curriculum "Basic Digital Education", including computational thinking, the government has made an important step. But schools will need support by integrating it into praxis. The Children's Congress is one successful example of short and medium-term activities in teacher and school education. It demonstrates how computational thinking can be taught integrated in several subjects and meets therefore an urgent need in the current situation in Austria.

3 THE CHILDREN'S CONGRESS

3.1 About the Congress

3.1.1 Aims and organization of the Children's Congress

The Children's Congress interweaves teacher education and in-service training with school practice, fosters computational thinking of all target groups, involves children as researchers and finishes with a sort of scientific congress and competition, where the best two or three projects are awarded. This is an innovative form of cooperative, cross-curricular and multidisciplinary teaching that combines different institutions and levels of education.

The main aim of the Children's Congress is to foster computational thinking and digital literacy in different subjects and related to several contexts of daily life. Hence, the main topic of the congress is always a general theme that could be related to and elaborated in every subject. In 2016 the congress theme was "Language – Pictures – Information" and in 2017 "Language(s)". The target groups are not only children of primary and lower secondary schools (grades 1 – 8) but also (prospective) teachers who shall acquire basic concepts of computer science and create different digital products. In order to implement computational thinking sustainably and for a broad audience, it should be integrated not only in certain subjects at school but also in teacher education and in-service training across all subjects. Hence, the Children's Congress is directed to different target groups – children, teachers, teacher students – and organized on different levels.

3.1.2 Organization

First of all, it is a "school-related event", as children from grade 1 to grade 8 are the main target group, which means that it is part of the regular lessons at school, builds on the regular subject-specific contents and has to be approved by the school authority, the regional Education Board. For the participating teachers the congress is organized as in-service training and for students of teacher education programs it is part of master courses related to (subject specific) didactics. Each project team consists of one class or group, one or two teachers of this class and two or three bachelor or master students, one of them, if possible, from the field of computer science. If there is no computer science student or teacher in the project team, they are supported by the staff of the Informatics Lab, a learning lab, that aims at attracting children for computer science [12]. The teams plan their projects and divide tasks individually. In the first two months of the school year, the organizing university sends an official call for projects to all relevant schools in the region: primary schools (grade 1-4) and secondary schools (grade 5-8). Every year they are invited to participate with projects created by their own under a new congress theme, which is open to all subjects. Teachers and classes from grade 1 to 8 can apply for participation with a project idea and are supported by the team of the Informatics Lab from finding ideas until the final event, the Children's Congress itself.

The Children's Congress is not a single event, but includes three main parts: the kick-off, the project phase and the final event, the Children's Congress itself. At the kick-off event teachers and teacher students meet for the first time, get a first short introduction into computational thinking, find and discuss project ideas, plan the project and the products they want to develop, divide necessary tasks and write a first project outline.

During the project phase between the kick-off and the final event (about four months), children and teachers get introduced into some basic computer science concepts fitting to their projects via workshops hold from the Informatics Lab staff. After this introduction they work together with teacher students at school and/or in the Informatics Lab. At the final event, the Children's Congress itself, the children present their projects and results to all other participants. Each class is divided in two groups. In the first half of the congress day the children of the first group remain at their station and present their project and product to the visitors. The second group walks around and visits the other projects. In the break the groups change their role. In this way everyone can visit all other projects. At the end of the congress, the two best projects, one for primary and one for secondary schools, are awarded. They are evaluated by a mixed jury (scientists, teachers, computer science students, and children) by regarding the criteria creativity, computational thinking concepts, the presentation and the (digital) product.

3.2 Computational Thinking Contents

Corresponding to Jeannette Wing's demand of teaching computational thinking as "fundamental skill for everyone, just like reading, writing and calculating" [18], all participants get an introduction into some basic concepts related to the field of computer science in general and especially to computational thinking. The underlying definition in this project is the one from Jeannette Wing, who defines computational thinking as "the use of computer science concepts to solve a problem in any domain"[18]. In the current study, this definition is the basis for the assessment if computational thinking has been fostered. The evaluation of the correct use of CT concepts within the projects by a jury was used as measurement. In several stations and workshops with hands-on materials and examples of everyday life the pupils and (prospective) teachers get a first and playful insight into some key concepts. Besides that, the classes elaborate also other topics that are relevant and/or necessary for their individual projects, e.g. graphics, software engineering, programming, 3D design and -printing etc. Depending on the previous knowledge, the age and the interests of the participants the introductory workshops are more or less intensive and deep. We use units and materials developed in the Informatics Lab [12] as well as from the project "Informatik erLeben" (Experiencing Informatics) [11], which are in part taken from CS Unplugged [4,20] and adapted for our needs. The workshops contain at least the following concepts:

Encryption: encrypting and decrypting simple words with a Cesar cypher wheel

Encoding: Morse code, traffic lights and color codes etc., encoding and decoding simple words

Binary numbers: converting binary numbers (4-5 digits) into decimal numbers

Modeling: understanding and designing simple activity-, entity-relationship- and class diagrams

Algorithms: simple algorithms of everyday life, e.g. describing the way to school etc., programming Beebots and Probots etc.

Logic: simple truth tables with symbols (✓, ×), yes/no and binary numbers 1/0, basic operations with AND, OR and NOT

Hardware: components of a computer, basics of data processing

Computational thinking is the common ground of the Children's Congress and shall be involved in all projects by applying at least one of the basic concepts listed above. This means, that participants do not only have to understand and build up knowledge on the computer science concepts but also apply them individually. The design of the Children's Congress focuses on the transfer process to implement computational thinking in different subjects.

4 METHODS AND RESULTS

4.1 Methodology

The goal of this study is to investigate, if the Children's Congress is able to foster informatics integration in school. Quantitative data were collected via questionnaires based on the triangulation principle. Pupils, teachers and students were asked about the event and its effects on using informatics integrated in school. At the end of the Children's Congress we collected data via paper-pencil questionnaires for teachers and pupils. To meet the requirements of all ages and target groups, three different questionnaires for pupils have been designed as well as an extensive questionnaire for teachers and another one for students. The data survey for students was an online version, which was available after the congress. For rating the implemented informatics concepts within the projects a data analysis has been conducted. For this, we analyzed the projects, to evaluate which computer science respectively computational thinking concepts have been integrated and if these concepts were used correctly on a basic level. The correct use of one or more concepts in the school projects is seen as positive indicator for the question if we can integrate and foster computational thinking at school. This is based on the assumption, that applying a CT concept needs a basic level of understanding of this concept.

4.2 The Participants and Projects

The participants of the first two Children's Congresses in 2016 and 2017 came from 20 different schools (10 primary and 10 lower secondary schools) and conducted 27 projects (Table 1). Two of the schools were private schools with alternative curriculum: the CreaVita primary school and the Waldorfschool Klagenfurt with primary and secondary school.

As the first Children's Congress in 2016 with the main topic "Language – Pictures – Information" was organized mainly for partner schools of the project "Informatics – A Child's Play?!" (12 of 17 schools), the previous knowledge in computer science and computational thinking was not uniform. The partner schools already had attended some workshops on different concepts whereas the "new" schools only got one introductory workshop. In the second year, 2017, the topic was "Language(s)" and the preconditions were similar, as half of the projects came from schools who had also participated in the year before. Table 2 shows the list of the conducted projects. Only one of them (Google Sketch Up) was not presented at the final event.

Table 1: Participants and Projects

Year	Pupils	Teachers	Projects	Schools (Grade)	
				1-4	5-8
2016	297	29	17	6	6
2017	218	18	10	4	4
Total	471	44	27	10	10

Table 2: Projects 2016 & 2017

Projects 2016	Grade
Software Engineering - Play to understand	3-6
City types	6
How do pictures come into the computer?	6
Labyrinth game	6
From a tinkering video to origami instructions	6
Aspects of a city in a city quartet	6
From eggs on a leaf to a butterfly	6
Geocaching and encoding	8
Italian regions	7
Board games - Safer Internet	5
Secret language	2
Encryption and algorithms	
Let's process: Modeling & programming of math	2
stories	2-4
Informatics by moving - Working with activity	8
diagrams	1
Google Sketch-up	
Informatics stations	
Fairy tales from all over the world	
Projects 2017	**Grade**
Modeling of experiments with acitivity diagrams	2
Fairy tales	3
Fun with Codes	4
Languages and their culture	6
We make radio	6
Luise's great adventure - a true story in 4	6
languages	8
We play with the Alps-Adriatic Area	4
Giving pictures a language	7
Language of mathematics	10
Creating digital travel guides	

4.3 Computational Thinking Contents

The teams had the task to apply at least one computer science concept in a basic form (as described in section 2.2) in their project. In total there were found 12 different concepts, 11 of them were computer science concepts and one can be categorized as "use of ICT", where standard software or apps were used to create and/or present the final products. It is positive, that 14 of 20 projects (70%) fulfilled more than the minimum. 8 projects used 2 concepts, 11 projects applied 3 and 2 projects even 4 concepts. The rest (6 projects) contained only 1 computer science concept. An analysis of the projects over the two years shows that the most applied concepts were algorithms and modeling followed by encoding and the use of different standard software and apps. Table 3 shows the concepts applied and figure 1 the number of projects including the different concepts.

Table 3: Computer science concepts in projects

Abbr.	CS Concept	Abbr.	CS Concept
MO	Modeling	GR	Graphic
AL	Algorithms	SE	Software Engineering
CO	Encoding	PRO	Programming
BI	Binary numbers	SEC	Security
VS	Encryption	MM	Multimedia
RO	Robotics	ICT	use of standard software

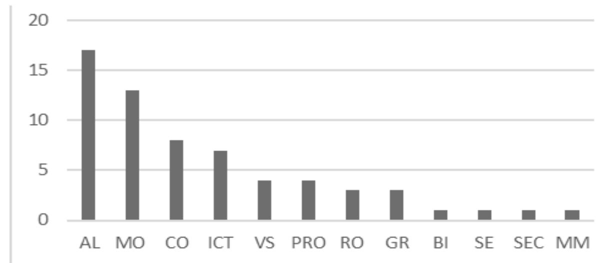

Figure 1: Number of projects including the CS concepts

4.4 Results of questionnaires

The Children's Congress is an impulse and opportunity for schools to teach informatics integrated in all subjects. It is designed as medium-term intervention and our results focus on the effects right after the event. In sum 28 teachers (3,6% male and 96,4% female) filled in the paper-pencil questionnaire, and 373 pupils (47,2% male and 52,5% female). The online questionnaire has been answered by 16 students (37,5% male and 62,5% female). The presented data has been collected in both events, but the study population of these events were disjoint. Schools that participated twice did this with different classes and teachers than in the year before.

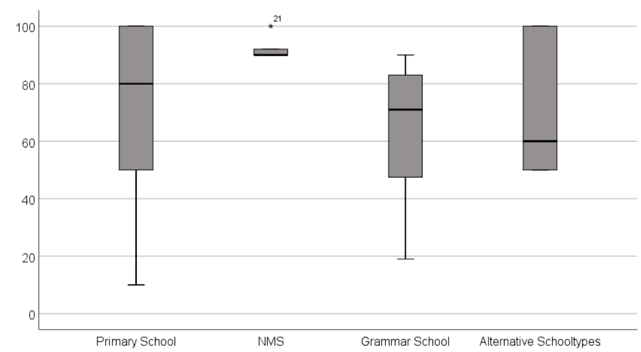

Figure 2: New impulses and school type

Teachers have been asked to rate on a scale from 0 (no effect) up to 100 (strong effect), if they think that the event gave new impulses for regular lessons. The agreement is in the upper third section (M=73,19; SD=28,486; N=26). The range is very high, from minimum 10 up to the maximum 100, so it was from great interest to take a closer look at this result. In particular, teachers from the NMS (New Middle School) rated the stimulating role of the children's congress very high (M=92,40; SD=4,336; N=5).

From the students' view the assessment of the impulse giving effect is similar to the teachers one (M=70,21; SD=29,208; N=14). Rating the usefulness of integrating informatics in other subjects on a scale from 0=not useful at all up to 100=very useful the results showed, that participating teachers (N=28) think this concept is very useful (M=95,96; SD=10,174). More critical but nevertheless positive, is the view on this concept from the student's perspective (M=74,64; SD=28,169; N=14). Teachers have been asked, if they will combine regular lessons with informatics in the future. No significant differences have been found between the school types (Chi-Square=8,036; p=,235). The teachers are very optimistic to combine regular lessons and informatics beyond the children's congress. The data show, that teachers from the school types NMS and alternative ones have a very positive opinion (figure 3).

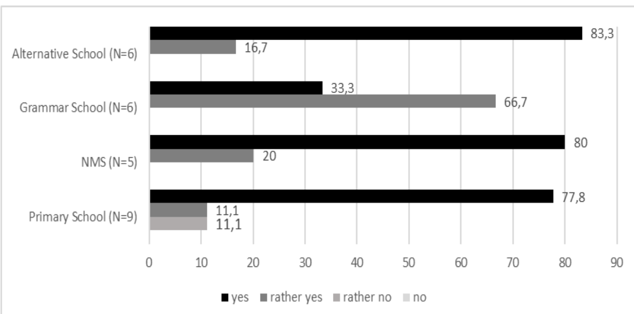

Figure 3: Regular Lessons & Informatics (N=26; in %)

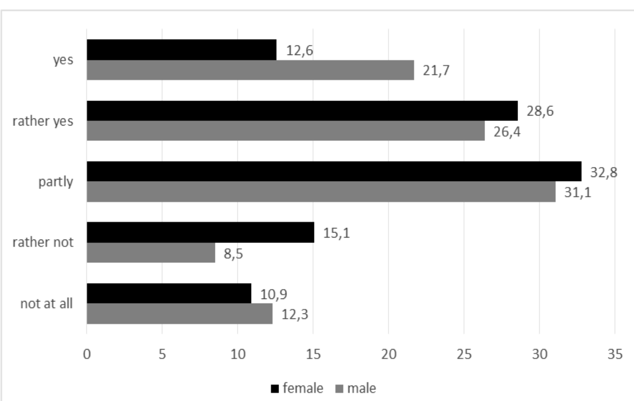

Figure 4: Fostering Children's interests in informatics: Gender (N=225; in %)

Pupils have been asked if the children's congress was able to strengthen their interest in informatics. Pupils from the primary schools are excepted for this question because of difficulties in understanding the word informatics. Analyses showed, that there is no significant gender-gap (Chi-Square 5,031; p=,284, n.s.). Nevertheless, descriptive results demonstrate, that much more male pupils (21,7%) agreed, that the event fosters their interest in informatics. On the other hand, twice as much female pupils said, that this was rather not the case. (Figure 4)

A significant school-specific difference in the interests in informatics was given (Chi-Square 24,257; p=,002; s.). For reasons of simplicity, answers have been grouped in the figure 6 in three categories: Yes (rather yes and yes), Partly (partly) and No (rather not and not at all). 63,8% of the pupils in NMS (N=58) said, that the Children's' Congress fosters their interests in informatics. Less than half of the pupils in Grammar School (N=99) agreed, and only one third of pupils of alternative school types (N=69).

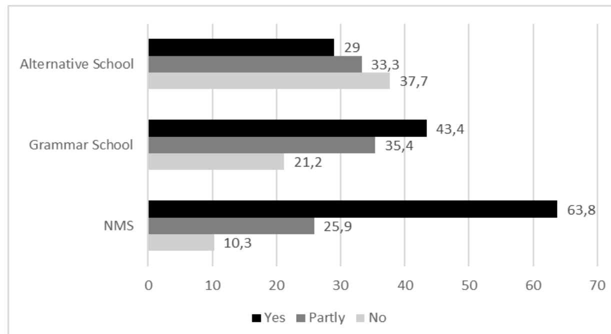

Figure 5: Fostering Children's Interests in Informatics: School types (N=226; in %)

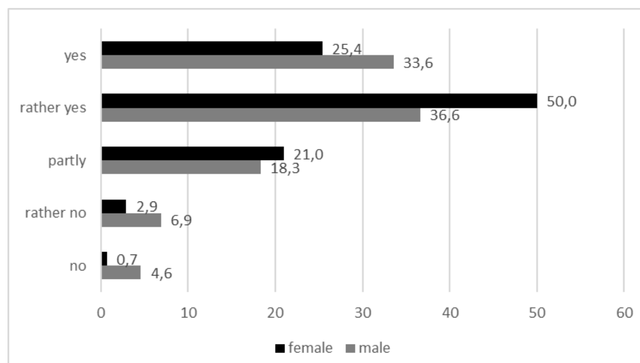

Figure 6: Interest in project topics: Gender (N=269; in %)

One reason for the effect, that the interests are fostered most in pupils of the school type NMS, can be due to the novelty value that the informatics topics had for them. So pupils were asked to rate, if the project topics were new to them. The assumption is that new topics are more fascinating for the pupils than the ones already known. There was no significant difference concerning the novelty value of the informatics issue and gender (Chi-Square = 3,318; p=,345; n.s.; N=128), neither between school types (Chi-Square=4,557; p=,602; n.s.; N=128). No significant correlation between fostering the interests and the novelty value of the topic can be found (Spearman-Rho=,145; p=,103; N=128). A possible impact on the result, that the interest in informatics can be fostered via the event, is the rating of the project carried out in class. Children have been asked, if they found the project's topic interesting. Data showed, that the topics are rated positive by the pupils (Figure 6). But there are no significant correlations between the interest in the projects' topic and the effect in fostering the interest in informatics (Spearman-Rho=,145; p=,103; N=128).

5 CONCLUSION

With the Children's Congress we have designed an innovative way to implement computational thinking in school. We focused on different target groups and developed a concept from which everyone can benefit: pupils, teachers and students. Teachers and pupils learn about informatics concepts and computational thinking. But far beyond this, the Children's Congress supports teachers within the transfer process to implement computational thinking in regular lessons and different subjects. With support from university staff, they can get closer to the theme, foster their knowledge and create awareness of computational thinking and how to implement it in regular lessons. Teachers get trained in the transfer process, the inhibition threshold to integrate computational thinking decreases and they get an idea of how the implementation process can work with low effort. Pupils learn basics of informatics concepts and computational thinking, create and carry out interesting projects, and learn how to present project results at a congress. The students, too, get trained in informatics concepts and computational thinking and have the possibility to gain additional practical experience during their studies.

The evaluation of the two congresses in 2016 and 2017 reveal some positive results. All schools want to apply the learned informatics concepts also in their further regular lessons. Teachers as well as students support the idea of integrating informatics in several, even non-related subjects. It was interesting that more computational thinking concepts than expected and required were applied in the projects. The favorite concepts of all schools were algorithms and modeling. It would be interesting to analyze in further studies, which concepts are able to foster computational thinking and interests in informatics the most. The Children's Congress seems to be a good concept to attract boys and girls equally to informatics, as no gender gap was found. Most schools, above all, new middle schools indicated, that the Children's Congress gave them new impulses for regular lessons and they think that it fosters interest in informatics. In view of these results the Children's Congress was successful and we could achieve our main aim of fostering computational thinking and digital literacy in different subjects.

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