The Children's Congress: Creative Computational Thinking to Promote Gifted Pupils

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Abstract: The Children's Congress is an event, developed to meet a demand for strengthening computational thinking and increasing the interest in STEAM (Science, Technology, Engineering, Arts and Mathematics) subjects. This congress brings teachers, university students and pupils together to work on interdisciplinary real-life problems. During these proceedings, the pupils slip into the role of researchers and scientists. The Children's Congress aims at inspiring pupils, students and teachers to work with computational thinking in different subjects, as well as promoting the concept of working in an inter- or transdisciplinary way. It is a core value of the Children's Congress that the project should challenge and benefit everyone involved. At university it was shown that students need special requirements in talent promotion to be successful: creating community, offering freedom and enhancing academic competence. In this paper we want to find out if the project offers these requirements and their effects. The findings show that the Children's Congress includes all pillars of gifted education and moreover that the pupils enjoyed these pedagogical approaches. Besides, the Children's Congress helps to detect new talents and trains all participants in computational thinking and cross-curricular project-based learning.

1 INTRODUCTION

Gifted pupils have by definition above average abilities enabling them to acquire new knowledge quickly and to understand new concepts almost immediately (Gronostaj et al., 2016). They already know 40-60% of the content that is being taught (Coleman and Cross, 2005) and they are usually fast learners, need minimal instructions and have an excellent memory (Harrison, 2004; Webb et al., 2008). These issues make it necessary to offer pupils projects in the classroom giving the possibility to do more than the usual tasks. One possibility to challenge gifted pupils in this way is to do inter- or transdisciplinary projects, which require their creativity and academic knowledge in a complex way. In doing so it is important to offer different and individual tasks for the pupils, because every pupil has different abilities and interests. If pupils can work in the right balance between the perceived challenges of the task and their own perceived skills a flow state can be entered. A flow state describes the optimal state in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process (Csikszentmihalyi, 1990).

One solution to achieve this advantageous state is the Children's Congress, which combines these challenges with computational thinking. The latter describes a problem-solving process with distinctive problem-solving techniques and general intellectual practices. It covers solving problems, designing systems and understanding human behavior by drawing on the concepts of computers (Wing, 2006). These concepts should increase the interest in computer science, correct possible misconceptions and work against existing fears and inhibitions concerning computer science and new technologies.

In university context Wolfensberger (2012) found out that gifted students call for a specific pedagogical approach by teachers. She formulated the three pillars of Honors Pedagogy: creating community, en-

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hancing academic competence, and offering freedom; (Wolfensberger, 2012). In this paper we want (1) to unveil if the Children's Congress offers the potential to provide these requirements and, if it does, (2) to reach the effects of these three pillars in the school context. Results of the questionnaires of 183 pupils were examined to answer the following questions:

1. Does the Children's Congress support participants to create a community, enhance academic knowledge and offer freedom for the pupils?
2. How are the pupils' experiences with these 3 pillars of Honors Pedagogy in the project?

2 THE CHILDREN'S CONGRESS

2.1 Aims

The concept of the children's congress was developed as part of the "Informatics - A Child's Play?!" project (Sabitzer et al., 2014; Sabitzer and Demarle-Meusel, 2018). The main aim of the Children's Congress is to foster and implement computational thinking in regular classes in the medium or long term. Computational thinking is understood as the application of IT concepts to various "non-IT" problems (Wing, 2006). Experience has shown that short-term interventions (e.g. individual workshops) have only minor effects. With its setting, the Children's Congress offers the possibility of a long-term discussion of a topic by working on a project for one semester. A specific feature is the collaboration of various stakeholders and target groups of education: these are scientists, university students, teachers and pupils. Such a collaboration creates synergies, which are beneficial for all target group. It is particularly important that project work implemented in the Children's Congress specifically supports pupils. It is encouraged that the Children's Congress has a different focus each year, where it should be emphasized that focus is chosen broad enough allowing to host a wide range of projects and subjects. The creativity of the participants is encouraged as soon as they come up with ideas. The only requirement is that the project idea must be linked to computational thinking. For this, the schools are supported by the university (scientists and students). The project implementation at school should be interdisciplinary and problem-based. In addition to the fun and learning success that the pupils have when implementing the project, the overriding goal is to promote interest in IT and STEAM. The highlight and conclusion of the Children's Congress is the congress day, on which all projects and developed products are presented and tried out. At the end a jury awards the best three projects. Besides promoting computational thinking the Children's Congress aims at detecting new talents and inspire interdisciplinary teaching. Furthermore, it interweaves teacher pre- and in-service training with regular school lessons in a way that anyone (any target group) can benefit or learn from each other.

2.2 Setup

The project teams are made up of pupils (aged 7 to 14 years), university students and teachers. The pupils have to work as researchers and developers. They have to solve a real-world problem and to develop an innovative, creative (digital) product. In this process they get support by their teachers and students from university. The students are from the education program or from the honors program of our university.

The project starts with the *Kick-Off Event*, where the teachers present the first ideas of their pupils. Based on these presentations project teams are built, which consist of one or two teachers and one or two students. Following this first *Kick-Off Event* the project work in the *Preparation Phase* starts. The pupils have half a year to work on their project. In this process they regularly visit the university to attend workshops in the STEM field and for students' support. At the end the final event brings together all teachers, classes and students: The *Children's Congress*. At this event the pupils present their ideas, their work and their final products, which can be tested by all attendees. A jury consisting of university professors evaluates the projects and awards the best three teams.

2.3 The Children's Congress 2019

Every congress has a main topic very general, which is open to every school subject. Thus, it is elaborated as interdisciplinary projects. At the Johannes Kepler University (JKU) in Linz (Austria), the topic of the 2019's congress was "From the problem to the solution: Computational Thinking in everyday life". A total of 230 pupils worked with 23 teachers and 12 university students on 12 projects. The participating pupils were from 12 different schools in Upper Austria and from grades 1 to 8. An overview about the projects and the participating pupils can be found in Table 1.

Most of the project ideas were developed and finalized at the *Kick-off event*. The pupils itself developed research questions during the *Preparation Phase*. This phase, where all of the project members

Table 1: The Projects presented at the 2019's Children's Congress at JKU Linz.

Projects	Pupils	Grade
12/4/3: How can a poet visit 12 countries on 4 continents in 3 minutes?	24	3
ABC - activity based coding	48	0-4
Audio & video factory	11	6+7
How can initial programming be developed for primary school children?	22	4
Interaction human and computer	16	6+8
Learning success and self-control with Bee-Bots	18	6
Learning with the micro:bit	6	22
My Garden App	24	5
My heart beats for you	19	5
Social bot – friendly robot experience	10	7+8
Traffic safety and urban planning using interactive models	12	8
Writing personal descriptions supported by diagrams	20	3

worked together, amounted from 10 to 20 hours per team in total. The time that was spent by the pupils, students and teachers in total for the project was between 20 and 50 hours per person.

In the project "*12/4/3: How can a poet visit 12 countries on 4 continents in 3 minutes?*" the pupils dealt with their home countries. They did research on the geography and culture among others. In this process they painted a big earth map where a robot was visiting one country after each other. The pupils "taught" the robot the traditional dance from each country, which was shown through its path. Additionally, class diagrams with useful information about every country were presented. The project bears this name since the involved pupils or their parents originate from 12 different countries located on 4 different continents, while the robot only takes 3 minutes for its whole journey. Figure 1 shows the map of the countries, some of the presenting children and visitors. Figure 2 shows an Ozobot with a passenger on it travelling across some of the countries. This Ozobot was also used in the following project.

In the project "*ABC - activity based coding*" the children from preschool to the 4th grade showed insights into programming languages by using different robots and software like Beebots, OzoBots, OzoBlockly, Scratch and Lego WeDo among others. This was done across all grades and was used in a wide range of teaching subjects to ensure interdisciplinarity. Therefore the pupils wrote for example, essays on robots in their German classes or discussed dimensions and geometry in Mathematics classes.

The "*Audio & video factory*"-project aimed at teaching the pupils the basics about movie editing software, downloading and manipulating videos, camera setting and file formats among others to strengthen their abilities to produce a movie. Next to the technical aims, a major goal of this project was

Figure 1: Project "*12/4/3: How can a poet visit 12 countries on 4 continents in 3 minutes?*" The robots with feathers in the flag's countries dance the traditional dances.

to deal with bullying. The final product was a short movie about bullying in school in particular about the awareness and the avoidance.

In the "*How can initial programming be developed for primary school children?*" the pupils tried different approaches to get to a first understanding of programming. In this process they compared different programming languages and robots.

The research question in the "*Interaction human and computer*"-project was how it is possible to com-

Figure 2: Project 12/4/3 - Ozobot travelling through countries.

municate with a robot. The pupils did a lot of research and at the end created a program to interact with a robot.

The pupils in the project "*Learning success and self-control with Bee-Bots*" developed different game-based programs to check their learning success. This included a memory, robots who check the answer to a given task or hot-potatoes-tasks (quizzes and puzzles). All challenges where designed interactively and in a user-friendly and motivating way.

The "*Learning with the micro:bit*"-project-team developed a "Who wants to be a milionaire"-game with questions regarding the classes' learning contents. The answers were then checked with the micro:bit.

The "*My Garden App*" is a smartphone app that helps with the gardening. It tells when to sow the different kinds of vegetables and fruits, when they are ready to harvest and gives other tips and hints for gardening. For trying different kinds of vegetables and fruits points can be gained, which may unlock more varieties.

The research question of the "*My heart beats for you*"-project is: How do i recognize friends that fit to me?' In this process the project team built a measuring device that determines pulse and oxygen concentration in the blood (saturation). The collected data is linked to a database using Excel macros, which are then assigned in a playful manner using psychological studies to create social links. The playful character and the exploration of social bonds was the focus of this project.

The "*Social bot – friendly robot experience*" developed a robot that intervenes when people argue. From the draft to the prototype, they dealt with the question of whether and to what extent digital media and new technologies can help in interpersonal relationships. Where does the authority of the machine begin and end, what rights, obligations, ethical principles must or can a robot notice?

In the project "*Traffic safety and urban planning using interactive models* the pupils visited and also photographed danger spots on the way to school. These danger spots were also closely examined in Google Maps. Subsequently this information was sketched on paper, where additionally small clay bricks served as models of the surrounding houses. By using robots, cars and pedestrians, various dangerous situations could be simulated on the street models.

In the project "*Writing personal descriptions supported by diagrams*" the pupils planned and prepared personal descriptions of their class mates with the help of class and activity diagrams. Figure 3 shows an activity diagram developed from a class and an object diagram. On the left side it describes the characteristics of an abstract person (name, age, profession ...) and on the right side a concrete person (Franz, 8 years, pupil ...).

Figure 3: Project Writing personal descriptions.

3 METHODOLOGY

In total 230 children participated in the Children's Congress 2019. They were all asked for feedback

on the Children's Congress and 183 (79.57%) were willing to complete a questionnaire. 84 out of these 183 described themselves as female, 97 as male and 2 did not mention a gender description. At the time of the study all pupils were between 6 and 16 years old (there is no knowledge about the age of one participant who did not want to specify her or his age) with an arithmetic mean of 11.08. The distribution of the age can be seen in Figure 4.

The participating teachers and students were also asked about the Children's Congress. A total of 16 teachers (7 males and 9 females) and 4 students (2 males and 2 females) accepted this invitation.

The focus of the evaluation lies in the promotion of gifted pupils. Therefore it was examined if the students experienced freedom of choice, enhancement of academic competence and creating of community. Moreover, the experiences with these freedom of choice, these enhancement of academic competence and these creating of community were investigated. To reach this aim the questionnaire contained 6 questions for the pupils. Two of them were open questions, which had to be answered by writing a short text. The other questions were to answer with a four- or five-point Likert scale as described below. The questionnaire for the teachers and students contained 3 questions, two of them were to answer with a five-point Likert scale and one with agreement or not.

4 FINDINGS

4.1 The 3 Pillars of Honors Education

4.1.1 Creating Community

In the project, creating a community is an important issue. The pupils work in groups and are in active exchange with their teachers and supporting students. For communication collaborative platforms are used where new ideas or problems can be discussed. In order to make the project visible to other pupils, there is the big public event at the end where the pupils can present their results.

The questionnaire contained one question where the pupils were asked for their own opinion how they worked together in the class. The pupils could answer with a five-point Likert scale (yes, rather yes, partly, rather not or not at all;) (see Table 2). The results given in Figure 5 and Table 2 show clearly that the Children's Congress definitly supports and strengthens the creation of a community.

4.1.2 Enhancing Academic Competence

The broadening of the own academic competence is of course a reason why gifted students want to participate in the project. Often pupils are focused on a specific subject when they start with the project, because they are used to it from school. But in the Children's Congress projects it is not enough to be good in one specific field of domain. It especially fosters the creativity and the out-of-the-box thinking. The pupils participate in projects on different and interdisciplinary subjects to ensure a higher competence in important subjects or dimensions of being a gifted pupil. Topics like innovation and entrepreneurship, networking or project management prepare the students for their further life. Combined with skills in computer science like programming or computational thinking, the students get a solid and important grounding for projects even in disciplines other than computer science.

The own research is a big part of every project. The students are challenged with real-world problems in the STEAM field and demanded a variety of approaches. Often students have to start with a lot of research, doing many experiments and finally create their own products that are presented at the final event (Hinterplattner and Sabitzer, 2018).

In the questionnaire the pupils were asked for their opinion if they learned something and enhanced their academic competence. The pupils could answer with a five-point Likert scale (yes, rather yes, partly, rather not or not at all;) (see Table 2). When asked about this, 74% (yes and rather yes) of the pupils stated that they had learned something. The details of the results can be seen in Figure 5 and Table 2 and show that the aim of enhancing academic competence was reached by most of the pupils.

In addition to the self-assessment by the pupils, the external assessment by the teachers and students was of interest. 55% of the teachers and students rated the learning progress of their pupils as very high, the rest rated it high. It is interesting to note that all the teachers and students surveyed stated that the pupils had acquired additional skills (e.g. presentation skills, social behavior, goal-oriented work) in addition to the subject-specific content.

4.1.3 Offering Bounded Freedom

In every project the pupils get their freedom to work on their interests in a specific framework. This approach is called bounded freedom. As mentioned before, this should be part of every gifted program, because the gifted pupils want to develop their own

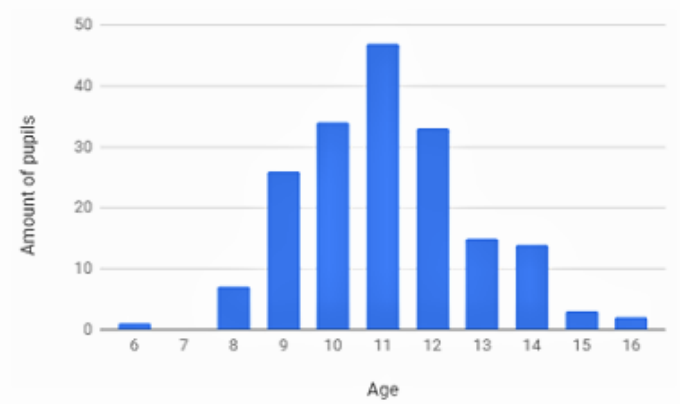

Figure 4: Distribution of the age of the pupils who participated in the study.

ideas. The teachers or supporting students will often define tasks or highlight problems in existing solutions, making it the pupils' task to improve or implement solutions to solve these challenges. In every project the gifted pupils bring in their own ideas and experiences . Working on these individual projects where there is no fixed solution or at least no fixed way to get to a solution gives a pupil a lot of room to try out skills and make precious experiences; all in a guided but open framework.

One question was dedicated to bounded freedom, where the pupils were asked if they were allowed to find their own tasks in the project. The pupils could answer with a four-point Likert scale, possible answers were: yes, rather yes, rather not or not at all; The four-point Likert scale was seen as more useful in this question, because it shouldn't be able to be neutral in this question. The results can be seen in Figure 5 and Table 2. According to these results most of the pupils could benefit from bounded freedom, although some more than in the other questions answered with no or rather no.

4.2 Experiences

One of the main concerns of the Children's Congress is to promote interest in STEAM among children and adolescents. It is therefore important to find out whether this target group has enjoyed the event. Children had been asked if they liked the Children's Congress. On a five-point Likert scale, 74% (N=183) answered with "very good" or "good". In addition it was from interest, which new interests pupils had gained from participating. They named e.g. programming, robotics, internet-security. The interests mentioned correlate with the content of the projects in which the students have worked. This shows very well that new interests can be generated through this format. An impressive result is that 48% of the pupils also worked on the project in their free time. The external assessment by teachers and students also showed that the students were very motivated (90% rated pupils' motivation as very high or high).

100% of the teachers and students surveyed (3 did not answer) state that talents can be promoted through the Children's Congress.

5 DISCUSSION

The data gained from the survey show that the format of the Children's Congress is suitable for achieving the intended results. The setting shows a high level of motivation both in the self-assessment and in the external assessment of the pupils. The pupils are interested in the topic and showed in the presentation at the end that they go beyond the performance required at school. The learning effect is also very satisfactory. It was not only possible to achieve positive effects in terms of content, the pupils showed at the presentations that they developed further in the area of so-called soft skills as well as 21st century skills.

6 CONCLUSION AND OUTLOOK

The Children's Congress and its preparation phase is a good way of fostering young talents in STEAM, not only at school but also at university level. We could detect all three pillars of gifted education in the project phase as well as in the final event. Furthermore, by interweaving pre- and in-service training of (prospective) teachers with regular school lessons it is possible that all participants and target groups learn from each other and everyone gets involved and trained in computational thinking and innovative project-based learning. Regarding the enhance-

Table 2: Distribution of answers to the questions regarding creating community, enhancing academic competence and offering bounded freedom (N=183).

Question	Answers					
	Yes	Rather yes	Partly	Rather not	Not at all	No answer
Creating Community: Did you work well together in the project?	115	48	12	0	3	5
Enhancing Academic Competence: Did you learn something in the project?	82	53	31	5	5	7
Offering Bounded Freedom: Were you allowed to find your own tasks in the project?	106	24	x	25	22	6

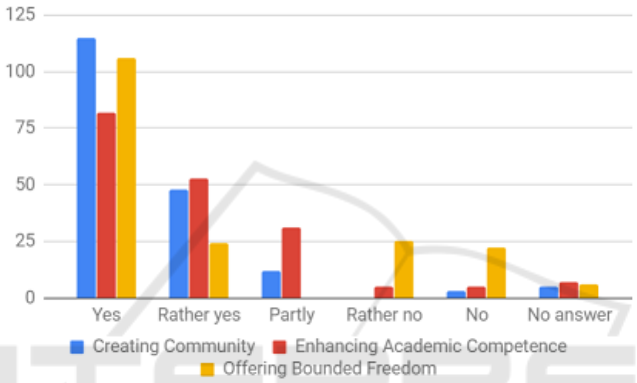

Figure 5: Distribution of answers to the questions regarding creating community, enhancing academic competence and offering bounded freedom.

ment of academic competence, especially computational thinking and computer science topics, it has to be mentioned, that the examples of the pupils are at a quite low level and sometimes incorrect in the sense of computer science. However, using diagrams of this field like activity or class diagrams, involves main elements of computational thinking. And that is, what we wanted to achieve and what we did, too: offering a motivating and playful introduction to computer science and the use of computational thinking in the sense of problem-solving in any domain.

The challenges we had in the past years, mainly regarding the communication between students, teachers and scientists as well as difficulties due to long distances between schools and university led us to revise the concept and offers. We are planning more online-training and -supervision as well as strong partners that can support us during the whole project. The revised concept will be described in a future paper.

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